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NATIONAL DAM SAFETY PROGRAM. APSHAWA MAIN DAM (NJ-00318), APSHA--ETC(U)
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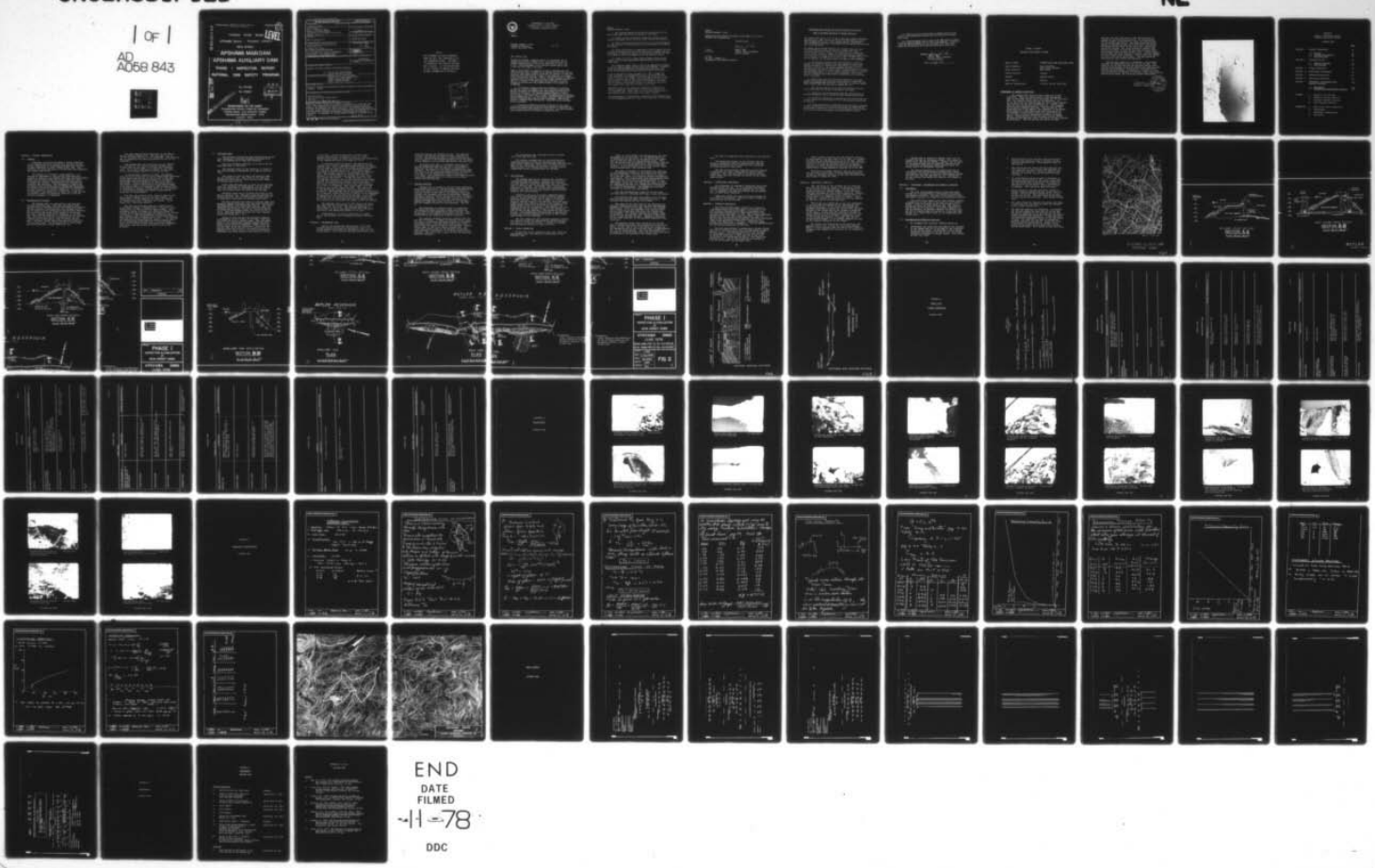

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LEVEL II

PASSAIC RIVER BASIN

APSHAWA BROOK, PASSAIC COUNTY

NEW JERSEY

APSHAWA MAIN DAM

APSHAWA AUXILIARY DAM

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

NJ 00318

NJ 00557

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE - 2D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

AUGUST 1978

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

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Phase 1 Inspection Report.

18. SUPPLEMENTARY NOTES

Copies are obtainable from National Technical Information Service, Springfield, Virginia, 22151.

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National Dam Safety Program Phase I
Dam Safety
Dam inspection
APSHAWA Main Dam, N.J.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.

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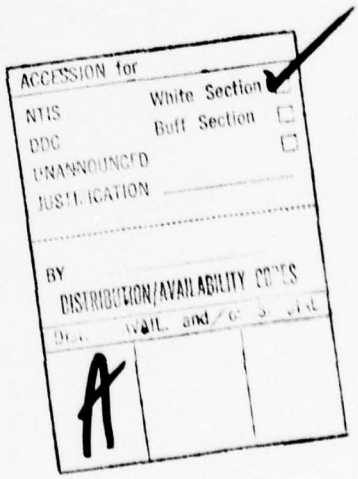


DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE--2D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO

NAPEN-D

Honorable Brendan T. Byrne
Governor of New Jersey
Trenton, New Jersey 08621

1 SEP 1978

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Apshawa Main Dam and Apshawa Auxiliary Dam in Passaic County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the condition of these dams is given on the first four pages of the report.

Based on visual inspection, available records, calculations and past operational performance, Apshawa Dam and Apshawa Auxiliary Dam, initially listed as "high" hazard potential structures, but reduced to "significant" hazard potential structures as a result of this inspection, are judged to be in poor overall condition. However, the dam's spillway is considered inadequate since 13 percent of the one half Probable Maximum Flood(1/2 PMF) (or 6.5 percent of the PMF) would overtop the dam. To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures, and studies within three months from the date of approval of this report. Any remedial measures necessary to insure the adequacy of the spillway and to prevent overtopping should be initiated within calendar year 1979. In the interim, a detailed emergency operation plan and warning system, should be promptly developed. Also, during periods of unusually heavy precipitation, around-the-clock surveillance should be provided.

b. Within three months from the date of approval of this report engineering investigations and studies should be made to investigate the source of the marshy areas downstream of both dams. Any remedial measures found necessary should be initiated in calendar year 1979.

c. The following remedial actions should be completed within the below listed times from the date of approval of this report:

(1) Within one year the deteriorated spillway concrete should be repaired and measures taken to minimize further concrete deterioration.

(2) Within three months the rip-rap and the top of the main dam near the left side wall of the spillway and all of the upstream rip-rap should be repaired.

(3) Within three months, an investigation should be made to determine if there are obstructions at the intake tower grate, the downstream gate house should be cleaned out and the outlet valve maintained and the degree of corrosion of the 14-inch diameter outlet pipe should be checked.

(4) Within one year all trees should be removed from within the limits of both the main and auxiliary dams and replaced with suitable ground cover.

(5) Within six months, public access to the dams should be limited to prevent possible damages that may result from vandalism. In addition, covers and locks should be put on the entrances to the outlet gate houses and the dam should be periodically patrolled by local police.

A copy of the report is being furnished to Mr. Dirk C. Hofman, New Jersey Department of Environmental Protection, the designated State Office contact for this program. Within five days of the date of this letter, a copy will also be sent to Congressman Robert A. Roe of the Eighth District. Under the provisions of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, thirty days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia, 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

An important aspect of the Dam Safety Program will be the implementation of the recommendations made as a result of the inspection. We accordingly

NAPEN-D
Honorable Brendan T. Byrne

request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely yours,

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

1 Incl
As stated

Cy furn:
Mr. Dirk C. Hofman, P.E.
Department of Environmental Protection

APSHAWA MAIN DAM (NJ00318) and APSHAWA AUXILIARY DAM (NJ00557)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 7, 12, 19 and 27 June 1978 by Langan Engineering Associates, Inc., under contract to the State of New Jersey. The state, under agreement with the U. S. Army Engineer District, Philadelphia, had this inspection performed in accordance with the National Dam Inspection Act, Public Law 92-367.

The Apshawa Dam and Apshawa Auxiliary Dam, initially listed as "high" hazard potential structures, but reduced to "significant" hazard potential structures as a result of this inspection, are judged to be in poor overall condition. However, the dam's spillway is considered inadequate since 13 percent of the one half Probable Maximum Flood(1/2 PMF) (or 6.5 percent of the PMF) would overtop the dam. To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures, and studies within three months from the date of approval of this report. Any remedial measures necessary to insure the adequacy of the spillway and to prevent overtopping should be initiated within calendar year 1979. In the interim, a detailed emergency operation plan and warning system, should be promptly developed. Also, during periods of unusually heavy precipitation, around-the-clock surveillance should be provided.

b. Within three months from the date of approval of this report engineering investigations and studies should be made to investigate the source of the marshy areas downstream of both dams. Any remedial measures found necessary should be initiated in calendar year 1979.

c. The following remedial actions should be completed within the below listed times from the date of approval of this report:

(1) Within one year the deteriorated spillway concrete should be repaired and measures taken to minimize further concrete deterioration.

(2) Within three months the rip-rap and the top of the main dam near the left side wall of the spillway and all of the upstream rip-rap should be repaired.

(3) Within three months, an investigation should be made to determine if there are obstructions at the intake tower grate, the downstream gate house should be cleaned out and the outlet valve maintained and the degree of corrosion of the 14-inch diameter outlet pipe should be checked.

(4) Within one year all trees should be removed from within the limits of both the main and auxiliary dams and replaced with suitable ground cover.

(5) Within six months, public access to the dams should be limited to prevent possible damages that may result from vandalism. In addition, covers and locks should be put on the entrances to the outlet gate houses and the dam should be periodically patrolled by local police.

APPROVED: James G. Ton

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

DATE: 1 Sep 78

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

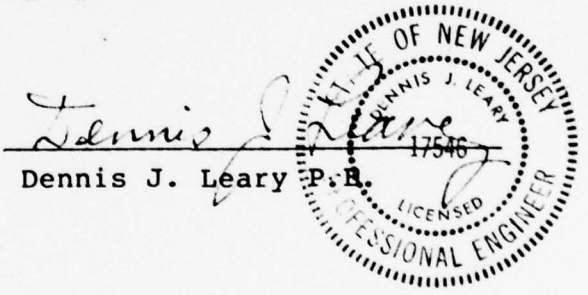
Name of Dams:	APSHAWA MAIN AND AUXILLIARY DAMS
Fed ID Numbers:	Main: NJ00318 Auxilliary: NJ00557
State Located:	New Jersey
County Located:	Passaic
Stream:	Apshawa Brook
River Basin:	Passaic
Date of Inspections:	7,12,19, and 27 June 1978

ASSESSMENT OF GENERAL CONDITIONS

The Apshawa Main and Auxilliary Dams are in poor condition. There are marshy areas at the downstream toes of both dams and no drains are shown for the auxiliary dam. The concrete cutoff may not be effective. It is not sure that the marshy areas are due to leaks through the cutoff or in the rock foundation; or a higher water table at the downstream side of the core. We recommend the following remedial measures: The drainage at the downstream toe of the dams at the locations of the marshy areas should be investigated and conditions improved. If necessary, relief wells should be installed to the top of rock to relieve hydrostatic pressure in deeper layers. Deterioration of the spillway concrete should be repaired and measures taken to minimize further concrete deterioration. The rip-rap and the top of the main

dam near the left side wall of the spillway and upstream rip-rap should be repaired. An investigation should be made to determine if there are obstructions at the intake tower grate. The downstream gate house should be cleaned out and the outlet valve maintained. The degree of corrosion of the 14-in-dia. outlet pipe should be checked. All trees should be removed from within the limits of both the main and auxiliary dams and replaced with suitable ground cover. Public access to the dams should be limited to prevent possible damages that may result from vandalism. Covers and locks should be put on the outlet gate houses. The dam should be patrolled by local police periodically.

The spillway capacity is inadequate. We estimate the dams can adequately pass only 6% of the PMF. The capacity of the spillway and the spillway design flood should be determined using more precise and sophisticated methods and procedures. The need for and type of mitigating measures should be determined. Around the clock surveillance during periods of unusually heavy precipitation should be provided, and a warning system established.



Dennis J. Leary P.E.

21 June 1978

OVER VIEW

APSHAWA MAIN AND AUXILLIARY DAMS

CONTENTS

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY REPORT

APSHAWA DAMS

SECTION 1 PROJECT INFORMATION

1.1 General

Authority to perform the Phase I safety inspection of the Apshawa Dams was received from the State of New Jersey, Department of Environmental Protection, Division of Water Resources by letter dated 26 May 1978. This Authority was given pursuant to the National Dam Inspection Act, Public Law 92-367.

The purpose of the Phase I investigation is to develop an assessment of the general conditions with respect to safety of the Apshawa Lake Dams and appurtenances based upon available data and visual inspection, and, determine any need for emergency measures and conclude if additional studies, investigations and analyses are necessary and warranted. The assessment is made using screening criteria established in Recommended Guidelines for Safety Inspection of Dams prepared by the Department of Army, Office of the Chief of Engineers. It is not the purpose of the inspection to imply that a dam meeting or failing to meet the screening criteria, is per se, certainly adequate or inadequate.

1.2 Description of Project

The Apshawa dams are identified as the main dam and the auxilliary dam. Both dams are masonry dams reinforced with upstream backfill and downstream rockfill. The main dam has a concrete free fall spillway section and is located at the southeastern end of Butler Reservoir. The auxilliary dam forms a dike across an old stream bed and is located about 500 ft southwest of the main dam. The main dam spillway is reinforced by two concrete side piers that also act as retaining walls for the rockfill and earth backfill, and, a central concrete pier. The main dam is 500-ft long and 22-ft high with a 12-ft wide crest. The auxiliary dam is 132-ft long and 16-ft high with a crest width of 12 ft.

The dams impound Butler Reservoir in the Town of Butler, Passaic County, N.J. The main dam is at 41° 01' 40" latitude and 74° 23' 07" longitude. The auxiliary dam is located at the same latitude but at 74° 23' 11" longitude.

The Apshawa Dams are classified as being "Small" on the basis of its reservoir storage volume, which is more than 50-acre feet, but less than 1,000-acre feet. It is also classified as "Small" on the basis of its total height, which is less than 40 feet.

In the National Inventory of Dams, the Apshawa dams have been classified as having "High Hazard Potential" on the basis that failure of one or both of the dams would cause excessive property damage to residences downstream, and could potentially cause more than a few deaths. Visual inspection of the downstream area shows that breach of the dam would cause little damage to residences which are located on high ground but could be hazardous to people utilizing Route 23. Accordingly, it is proposed to change the Hazard Classification Potential to "Significant".

The dams and reservoir were formerly owned by the Butler Water Company and used for water supply. We understand it is now owned by the County of Passaic, 317 Pennsylvania Ave., Paterson, N.J. 07503. It no longer has a functional purpose.

The main and auxiliary dams are located across stream beds leading to Apshawa Brook. They were originally built in 1910 as concrete masonry dams. From available records it appears the dams are founded on natural ground and the spillway and abutments are founded on bedrock. Cracks and movements occurred and they were repaired, and reinforced with rolled-earth backfill upstream and rockfill downstream in 1912. The spillway was repaired and strengthened by adding concrete piers at the downstream sides and center of the spillway. There is a 14-in-dia outlet pipe through the embankment with valves and gate houses at theleft side of the spillway.

1.3 Pertinent Data

The following information was obtained from visual site inspection, reference documents provided by NJ DEP, and examination of maps and airphotos.

The area of Butler Reservoir is 43 acres and the watershed area is 790 acres.

The maximum length of the reservoir is 2,500 ft. The total storage is estimated to be approx 850 acre feet.

The crests of both the main and auxiliary dams are at elevation 773+. The crest of the free-fall spillway is at elevation 770.9 and the total length of the spillway is 50 ft.

Steel rods and pipes are in place on the spillway crest for placement of flash boards. At the time of the visit there were no flashboards and one inch of water was flowing over the crest of the spillway.

Tailwater level was 21 ft below the crest of the dam at elevation 753. The water from the spillway was flowing on rock. The 14-in-dia bottom outlet pipe is of negligible importance for passing flood water.

The main and auxiliary dams are concrete dams with unequally spaced buttresses that have been covered with upstream backfill and downstream rockfill. The total cumulated length of the main and auxiliary dams, not including the spillway, is 582 ft. The crest width is 12 ft and the maximum height from crest to toe is 22 ft. Upstream slopes are 2 hor to 1 vert and the downstream slopes are 1 to 1.

Zoning of both the main and auxilliary dams is a consequence of the history of the dams. The dams were built in 1910 as concrete dams. The buttresses shown on the drawing were probably added when some doubts on the stability appeared, however, they are too far apart to be very effective. The top of the concrete dam, which now acts as a concrete core is reported to be at el 771.8. In 1912 a rolled-earth embankment was added upstream and sloped at 1.75 hor

to 1.0 vert. It was covered with a rockfill and placed rock paving to a slope of 2 hor to 1 vert. Rockfill and a layer of placed rock paving was constructed on the downstream faces at a slope of 1 to 1.

A concrete cutoff is shown on the drawing on the typical cross section immediately upstream of the 1910 concrete dam. This cutoff wall which is shown as founded on rock and the concrete wall and downstream rockfill are shown as founded above rock. The control works also seem to have been built in two stages in 1910 and 1912. The present system is located near the left abutment of the spillway and includes an intake tower (new outlet gate house). Inside the tower is a 14-in. hub gate closing a 14-in. cast-iron pipe that passes through the rolled-earth backfill and the concrete core wall to an access pit and a valve (old outlet gate). The intake is reported to be of el 753.2 and protected by a 3 ft x 2 ft grating. The intake tower is in the reservoir and can be reached by boat. The access pit to the downstream regulating valve was open but full of debris. The upstream face of the spillway is backfilled to el 768 with rolled earth and is similar to the embankment. The spillway is the old 1910 concrete dam. It is founded on bedrock and strengthened by two end piers and side walls that act as retaining walls for the backfill and by a central pier which does not appear on the old drawing.

The spillway crest is at el 771± and is not level. The right side of the spillway crest is about one inch lower than the left side. The upstream approach to the spillway is three feet below crest level and paved with rock. The downstream channel is on rock.

Flashboards do not seem to have been in recent use on the spillway crest although provisions had been made.

SECTION 2 ENGINEERING DATA

Data on the design and construction of the 1910 concrete dam is practically non-existent, and is obtained indirectly through the information from its 1912 reinforcement. This concrete dam had insufficient crest

elevation and was not founded on rock. The upstream face was cracked and was patched before backfilling in 1912. No engineering data is given concerning the type or quality of the foundation material or the extent of the damage to the concrete dam between 1910 and 1912.

No engineering data is available concerning the design assumptions used for the 1912 reinforcement. This does not mean that the design is necessarily inadequate. The safety of the design depends mainly upon the quality of the foundation material for the concrete core wall and the downstream rockfill which has a 1 to 1 slope. The construction seems to have been carefully controlled although there is a scarcity of written reports and descriptions.

2.1 Regional Geology

Apshawa Dam is located in the New Jersey Highlands physiographic province. The New Jersey Highlands extend across the state in a northeast-southwest direction from the border of New York to the Delaware River and includes the northwest portions of Hunterdon, Passaic, and Morris Counties and the southeastern parts of Warren and Sussex Counties. This province is part of the New England Physiographic Province and lies between the Appalacian Ridge and Valley Province to the northwest and the Piedmont Province to the southeast. See Fig 3.

The Highlands are characterized by rounded and flattopped northeast-southwest ridges and mountains up to 1,400 ft high separated by narrow valleys. The orientation of the valleys are usually, but not always controlled by the underlying geologic structure.

The regional geologic structure reflects the very old age of bedrock. A number of regional faults cross the area in a northeast southwest direction, including the Ramapo Fault; the more than 30 mile long fault scarp forms the eastern border of the province. Faults control many of the river valley orientations. The relatively uniform slope of the mountain elevations, from northwest to southeast, is a direct result of the faulting. The entire area is part of the now dissected Schooley Peneplain.

The Pleistocene Age Wisconsin glacier covered all of the dam site area.

The glacier stripped most of the existing overburden and weathered rock and uncovered the numerous hard bedrock knobs and ridges seen throughout the province. Most of the side-slopes in the area are covered with heavy boulder tills (ground moraine), whereas glacial outwash and recent alluvium cover the valleys.

2.2 Site Geology

The Apshawa Dam and its reservoir are located in a glacially excavated basin. Rounded and glacially striated bedrock is exposed throughout the reservoir, the main dam site and at the auxiliary dam site located west of the main dam. Overburden cover, consisting primarily of glacial till, is very thin and typically occupies only the low sections between exposed bedrock knobs in the valley bottom.

Bedrock in the area is a hard, competent gneiss with a well developed and distinct gneissic banding. Gneissic folds and swirls can be seen in the bedrock below the spillway. There are a number of low subparallel bedrock ridges in the dam site area with steep sloped south faces and more gentle north sloping faces. These slopes reflect the direction of movement and plucking action of the glaciers. The glaciers are also responsible for the removal of most of the weathered rock at the surface and only a thin weathered zone could be seen. The predominent discontinuity in the bedrock follows the gneissic banding and strike at N60° W and dips steeply to the southwest.

The site inspection and available drawings indicate the concrete cutoff is constructed on bedrock and the core wall is on natural ground. A sketch of presumed site geological features is given in Fig 4.

SECTION 3 VISUAL INSPECTION

At the time of our inspection the water level was approximately one inch above the lowest part of the spillway crest.

There is a wet marshy area downstream of the left embankment of the main dam. It is approximately 50 ft downstream of the toe of the dam and at the lowest part on the left bank of the discharge brook. This wet and marshy area corresponds to the probable location of a 2 ft x 2 ft blind stone drain shown on the 1912 drawing. A wet and marshy area is also located immediately downstream of the auxiliary dike.

No signs of movement or settlement were observed on the embankments except on the section near the left spillway side wall. In this area, and for a length of a few feet, there are traces of erosion and possibly overtopping. This erosion goes down approximately three feet below the crest and the downstream face of the upper part of the rock fill has fallen down. It does not appear likely that this damage was caused entirely by overtopping and may be a consequence of vandalism or a lack of maintenance. The damage may have been increased by erosion and overtopping.

The top and downstream slopes of the main and auxiliary dam are overgrown with small trees and bushes.

The spillway and side walls appear to be the most sensitive part of the whole retaining structure. The concrete has spalled and has fine cracks.

The faces of the side walls of the spillway, immediately downstream and at the top show some seepage. Seepage also occurs at the upper face of the spillway wall itself. It is not possible to be certain there are no leaks below where the water was flowing over the spillway. The central concrete pier shows traces of erosion at the concrete lift levels and some water seems to seep through the pier. Seepage is occuring at the right side wall at the spillway foundation rock interface.

The upstream intake tower could not be visited and is probably used only for maintenance of the outlet valve. At the time of our visit water was flowing at the downstream end of the 14-in-dia pipe, on approximately 1/3 of the cross section. The flow was probably restricted by the downstream valve, but may also restricted by plugging of the grating at the intake tower.

No trace of landslides were observed in the reservoir area.

The downstream channel of the spillway and the brook are generally clear of obstructions. The few boulders and debris in the brook are not considered as restrictions to flood flow.

The dam was previously inspected by Brown-Pandullo & Associates on 3 April 1968 and was found in good condition. The visit was made at the period of peak flood, which may have limited the extent of the visual observations.

SECTION 4 OPERATIONAL PROCEDURES

No information is available concerning operational procedures for the dam. If it is assumed the valves are for regulation of the flow passing into the brook, i.e. to maintain a minimum flow during the dry season, this is efficiently achieved.

Additional flood flow that could pass through the 14-in pipe is negligable. Safety in case of flood is governed only by the spillway.

SECTION 5 HYDRAULIC/HYDROLOGIC

The hydraulic/hydrologic evaluation is based on a spillway design flood (SDF) equal to one half of the full probable maximum flood (PMF) in accordance with the evaluation guidelines for dams classified as significant hazard and small in size. The original hydrologic design data for this dam is not available. The 1/2 PMF has been determined by developing a synthetic hydrograph based on the maximum probable precipitation of 22.5 inches (200 square mile - 24 hour). Hydrologic Computations are presented in Appendix 3. The 1/2 PMF determined for the subject watershed is 2552 cfs.

The main dam spillway is essentially a broad crested weir with a length of 50 ft and a maximum depth of approximately 2.5 ft. The maximum capacity of the spillway for this depth is 621 cfs which is less than the SDF. It should be noted that a small portion of the crest of the dam is at elevations as low as 1 foot above the spillway crest. Top of dam elevations are typically 2 ft to 2.5 ft above the spillway crest.

Flood routing indicates that the dam will overtop by approximately one foot under the 0.5 PMF. We estimate that the dam can adequately pass 6% of the PMF. However, by raising the top of the dam elevation in that portion that is 1 ft above the spillway crest to elevations equivalent to that typically found along the dam crest could result in dams adequately passing 17% of the PMF.

Preliminary drawdown analyses indicate that using the 14-in-dia outlet pipe, it would take approximately 15 days to drawdown the water to half the existing height and 32 days to empty the lake.

SECTION 6 STRUCTURAL STABILITY

The side walls of the spillway act as retaining walls for the rockfill, which is an essential feature of the stability of the spillway. The available information does not indicate whether or not the walls have been designed for this loading condition. However, no indications of instability were observed and it is likely there is an adequate factor of safety. There is however, a threat to the stability from overtopping at the left side of the spillway wall.

The marshy area downstream of the left embankment of the main dam corresponds to the approximate area of the blind drain. It is likely this seepage and attendant hydrostatic uplift may involve only the upper portion of the ground and may be related to plugging of the drain. In any case this should be checked to ensure stability of the downstream slope and that conditions do not worsen with time. Although the slope of the downstream rockfill is steeper than current practice would permit, it is probably adequate as long as the loading conditions do not change.

The marshy area downstream of the auxiliary dam appears to be in the area of the old stream channel. There is likely seepage under the dam at this location because of the absence of a cut off, or, an ineffective cutoff.

Apshawa Dam is located in Seismic Zone 1 of the Seismic Zone Map of Contiguous States. The degree of stability of the dam is unknown. However, on the basis of our observations and the available records we are not confident conventional safety margins exist for either static or earthquake loadings.

The bearing pressure at the downstream area is relatively high and earthquake shaking could induce settlements, and leaks by relative displacement between the core wall and the upstream cut off. Evaluation of such factors are beyond the scope of this phase of the work.

SECTION 7 ASSESSMENT, RECOMMENDATIONS/REMEDIAL MEASURES

7.1 Assessment

The 1912 reinforcement seems to have been made as best as it was possible to strengthen the existing and damaged strucutre. The fact it has stood for more than half a century is a good but not sufficient criteria.

The blind drains shown on the 1912 drawing indicate a recognition at the time of the need for such drains. However, there are marshy areas at both dams and no drains are shown for the auxiliary dam. The concrete cutoff may not be efficient. By visual inspection it was not possible to determine whether the marshy areas are due to leaks hrough the cutoff or in the rock foundation; or a higher water table at the downstream side of the core.

7.2 Recommendations/Remedial Measures

We recommend the following remedial measures:

1. Investigate the conditions and improve the drainage at the downstream toe of the dams at the locations of the marshy areas. If necessary, relief drains should be installed to the top of rock to relieve hydrostatic pressure in deeper layers. This should be done very soon.

2. Deterioration of the spillway concrete should be repaired and measures taken to minimize further concrete deterioration. This should be done in the future.

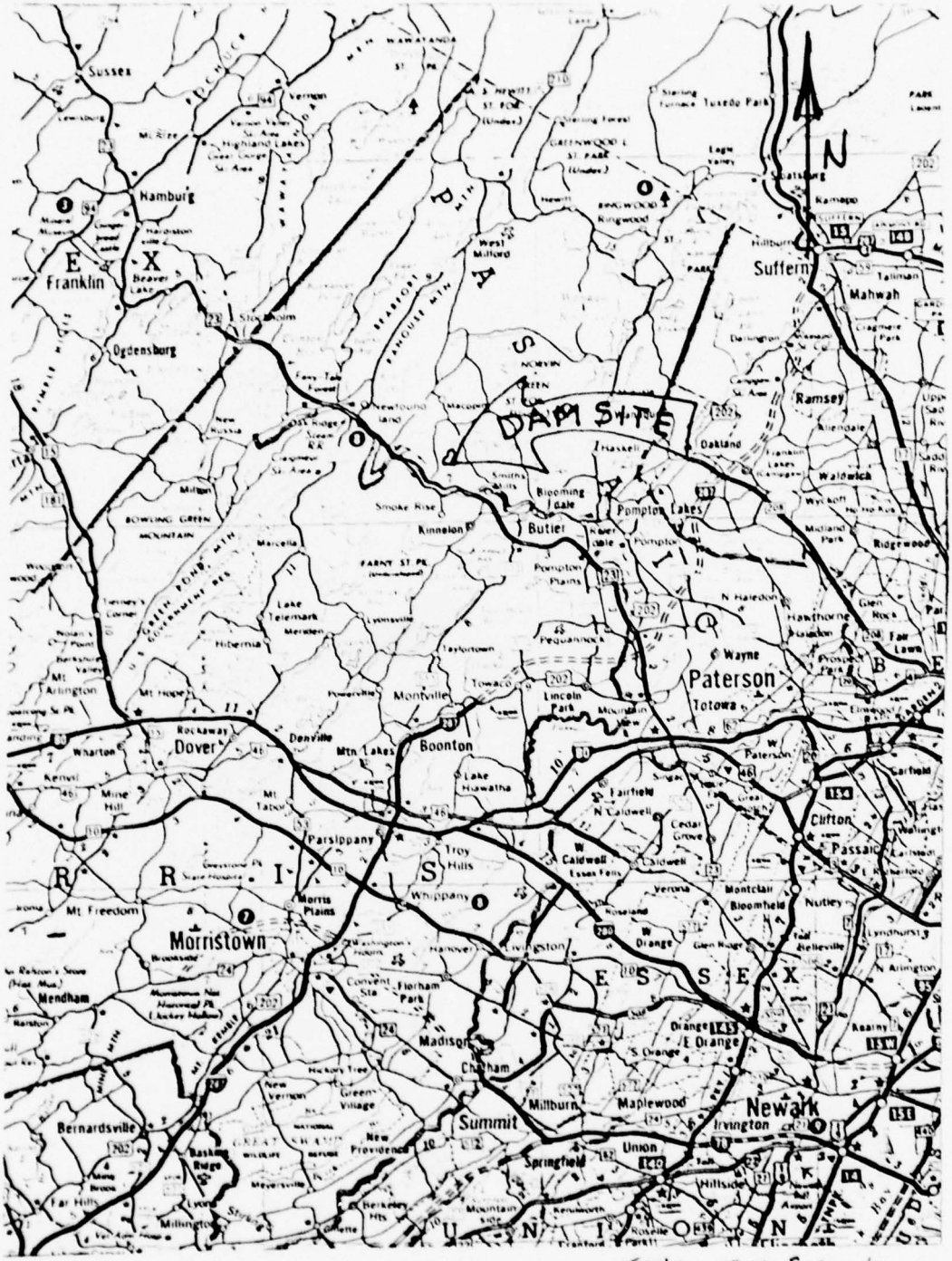
3. The rip-rap and the top of the main dam near the left side wall of the spillway and upstream rip-rap should be repaired. This will require replacement of missing rip-rap and should be done very soon.

4. An investigation should be made to determine if there are obstructions at the intake tower gate. The downstream gate house should be cleaned out and the outlet valve maintained. The degree of corrosion of the 14-in-dia. outlet pipe should be checked. This should be done very soon.

5. Public access to the dams should be limited to prevent possible damage that may result from vandalism. Covers and locks should be put on the outlet gate houses. The dam should be patrolled by local police periodically. This should be done soon.

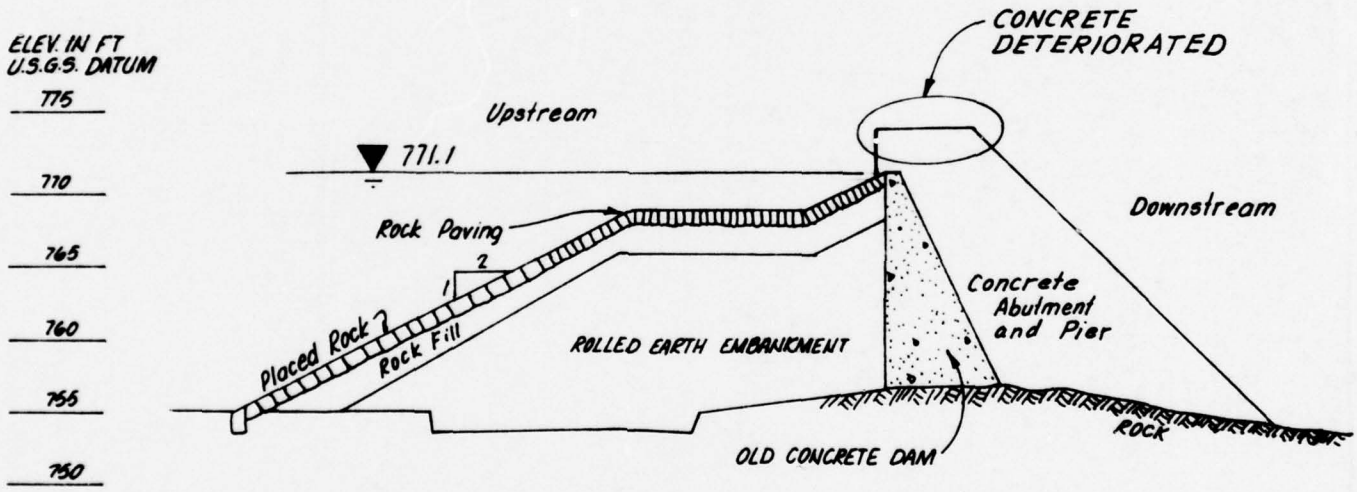
6. All trees should be removed from within the limits of both the main and auxiliary dams and replaced with suitable ground cover.

7. The spillway capacity is inadequate. We estimate the dam can adequately pass only 6% of the PMF. The actual capacity of the spillway and the SDF should be determined using more precise and sophisticated methods and procedures. A more detailed and extensive topographic survey of the dam should be made. The need for and type of mitigating measures should be determined. Around the clock surveillance during periods of unusally heavy precipitation should be provided, and a warning system established. This should be done very soon.



REGIONAL VICINITY MAP
APSHAWA DAMS

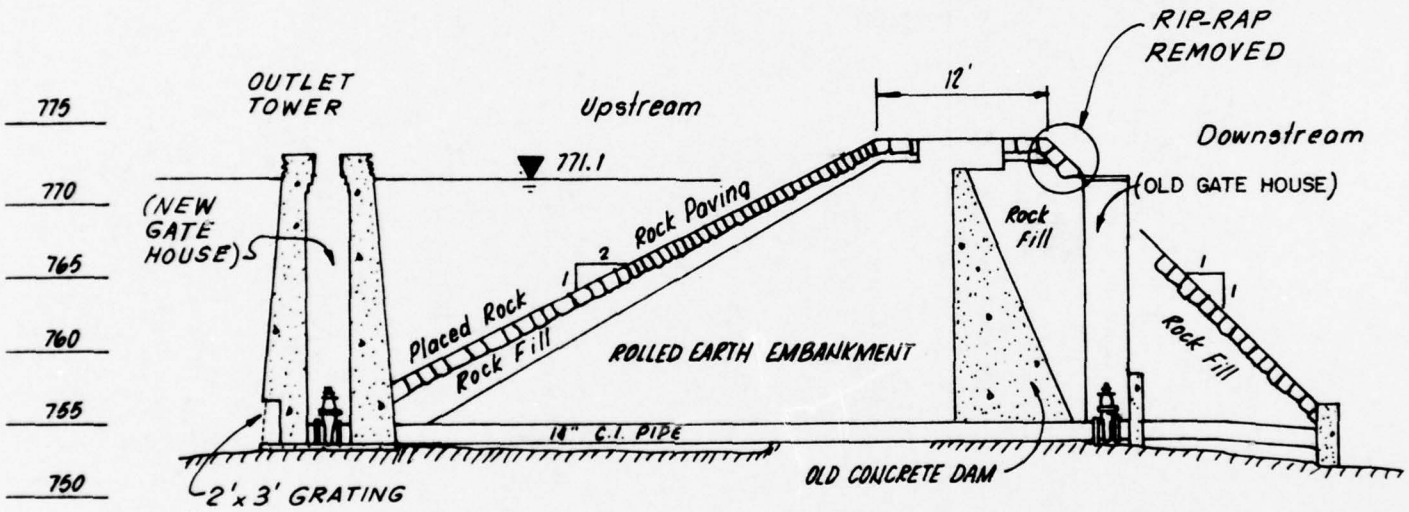
Fig 1



SPILLWAY - CROSS SECTION

SECTION A-A'

0 5 10 15 20 25 ft



GATE HOUSE - CROSS SECTION

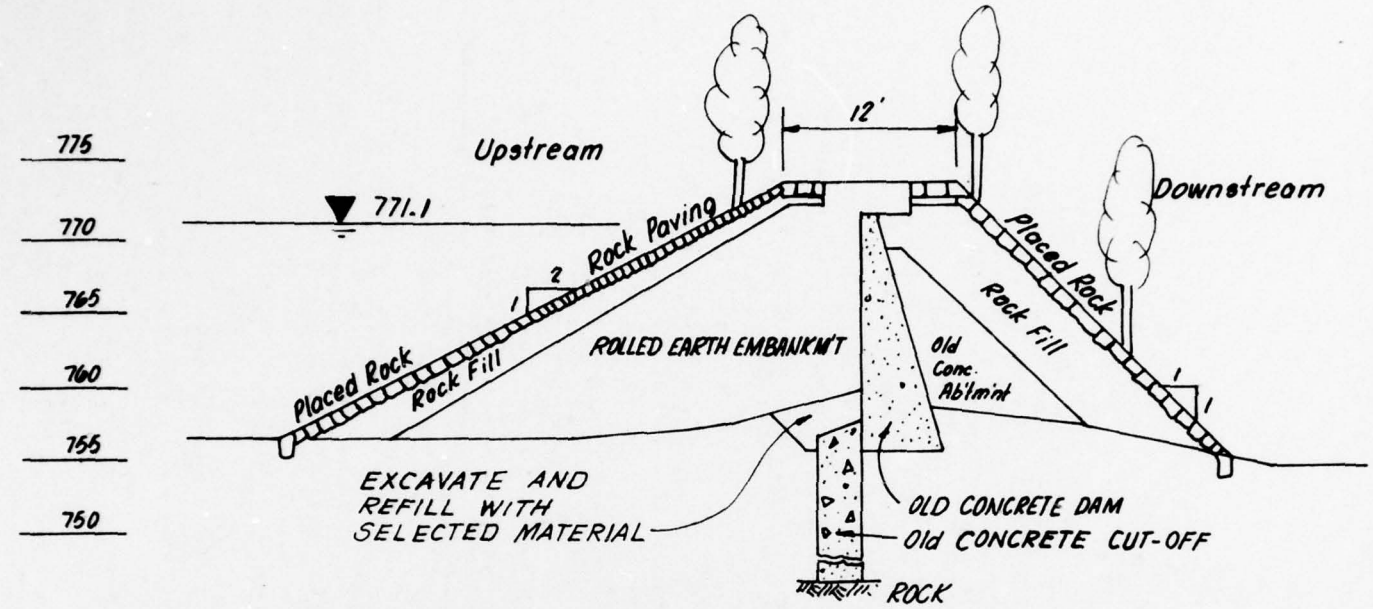
SECTION B-B'

0 5 10 15 20 25 ft

7

BUTLER

WATER LEVEL =



MAIN DAM-CROSS SECTION

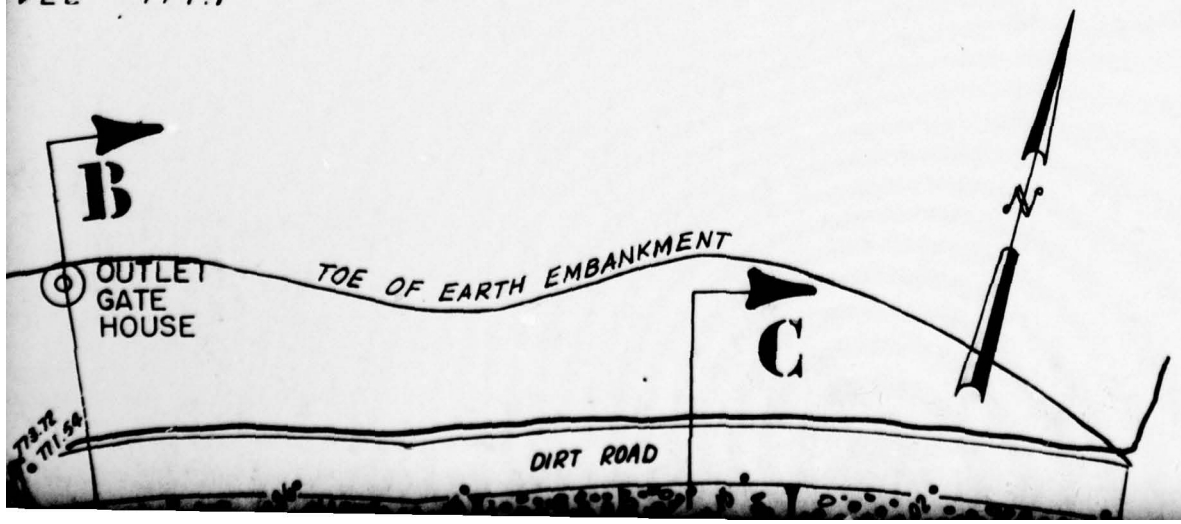
SECTION C-C'

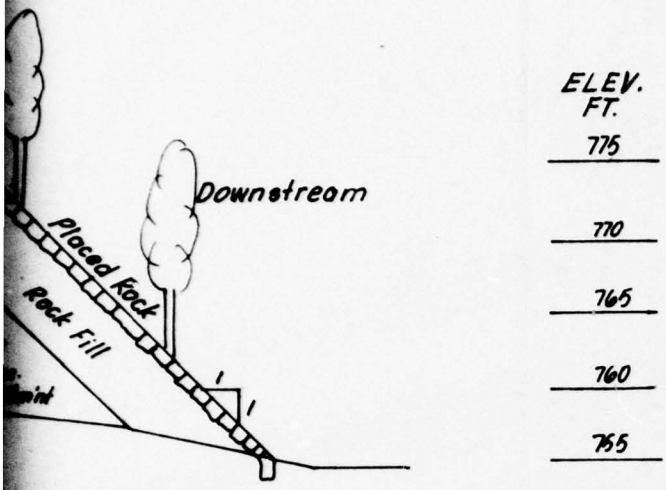
0 5 10 15 20 25 ft

3

? RESERVOIR

TVEL = 771.1





ELEV. FT.
775
770
765
760
755
750

CONCRETE DAM
CONCRETE CUT-OFF

SECTION
-C'

25 ft

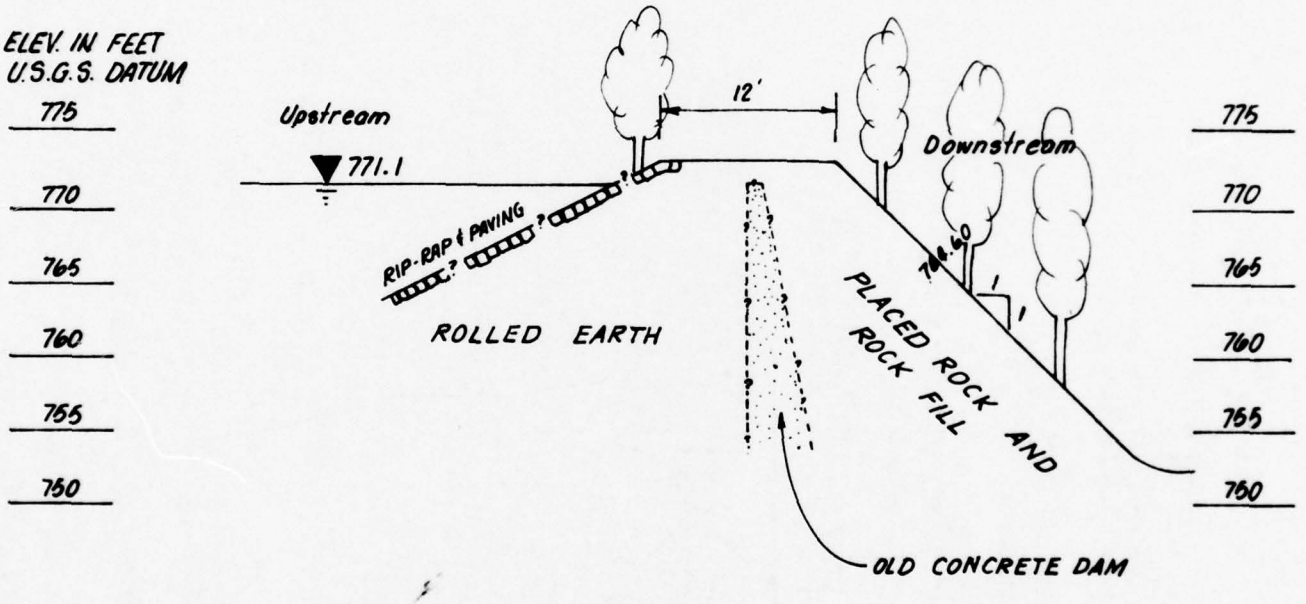
DATE	DESCRIPTION	NO.
REVISIONS		

PROJECT

PHASE I
INSPECTION & EVALUATION of NEW JERSEY DAMS

APSHAWA DAMS
JUNE 1978

REFERENCE:
PLAN SHOWING REINFORCEMENT OF THE CONCRETE DAM OF THE

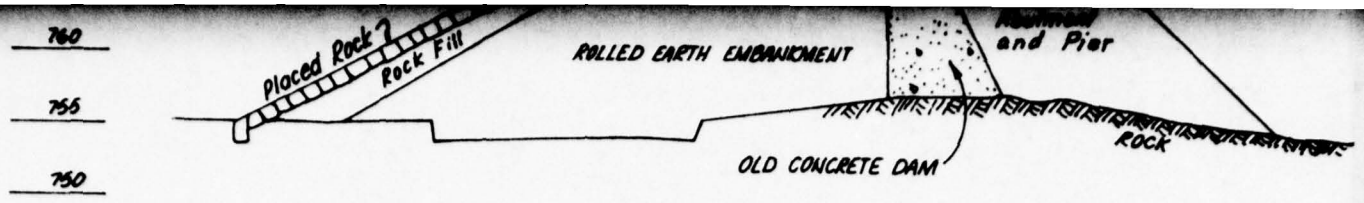


AUXILLIARY DAM - CROSS SECTION

SECTION D-D'

0 5 10 15 20 25 ft

5



SPILLWAY - CROSS SECTION

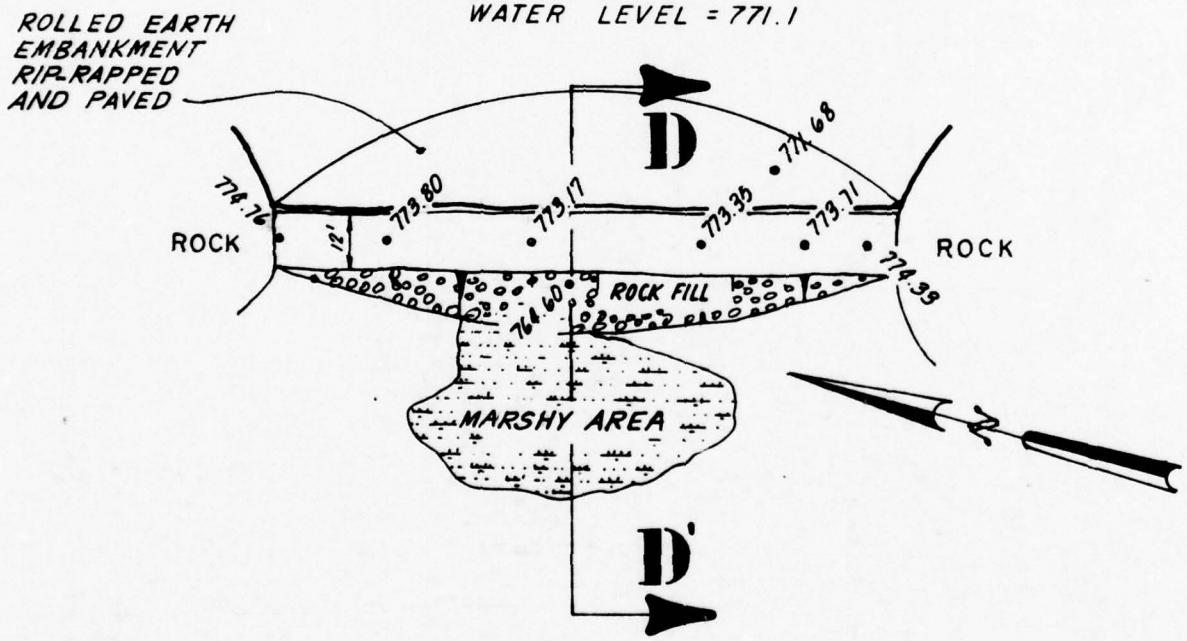
SECTION A-A'

0 5 10 15 20 25 ft

1

BUTLER RESERVOIR

WATER LEVEL = 771.1

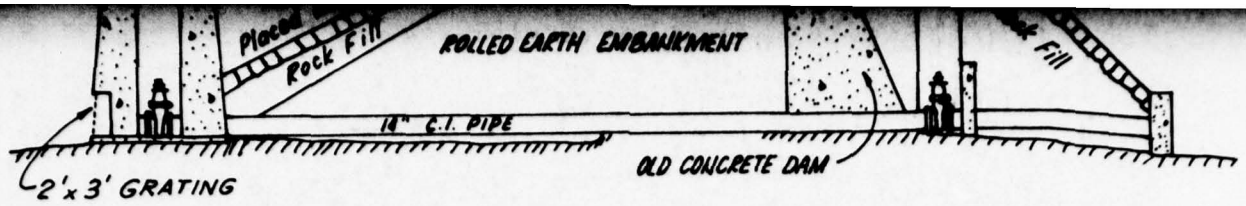


AUXILLIARY DAM

PLAN

0 10 20 30 40 50 60 70 80 90 100 ft

6



GATE HOUSE - CROSS SECTION

SECTION B-B'

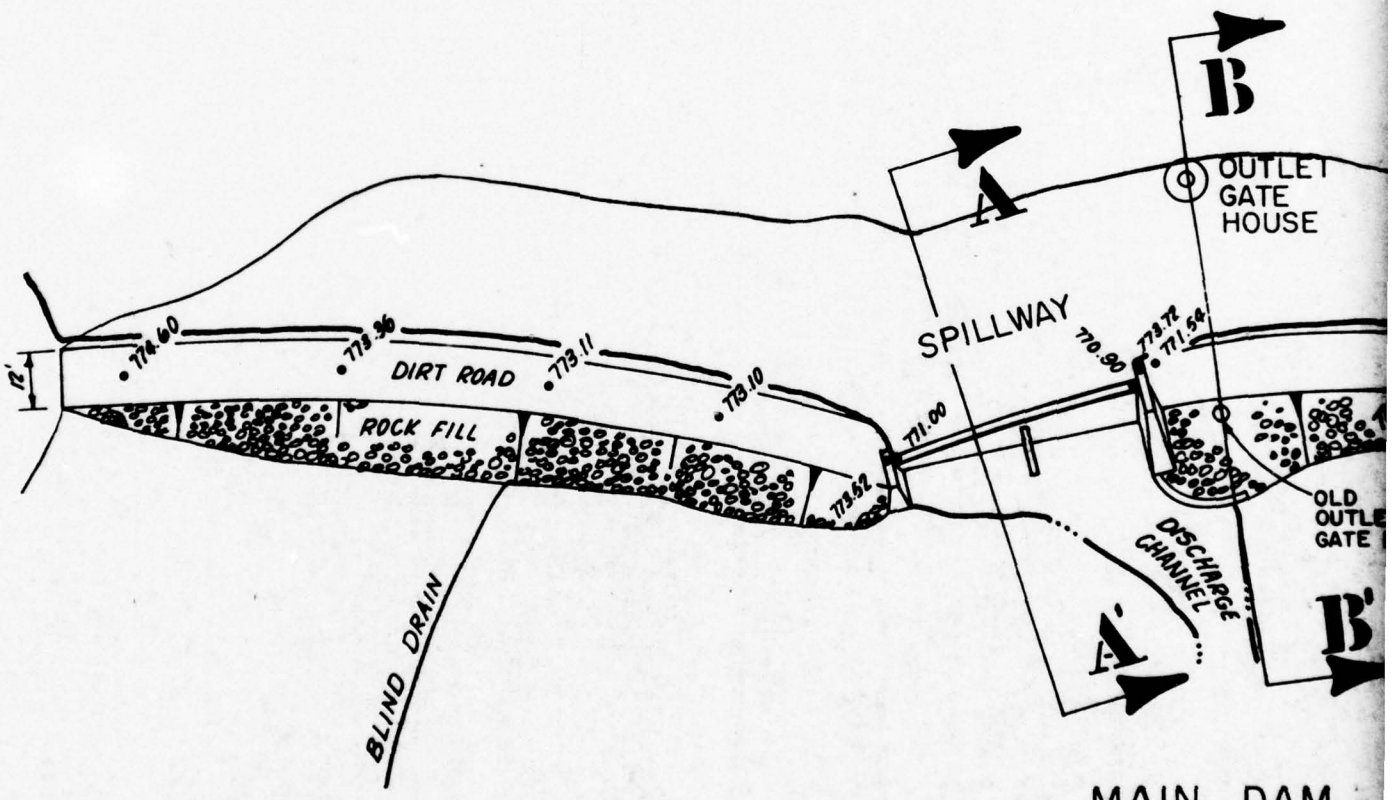
0 5 10 15 20 25 ft

3

2

BUTLER R E

WATER LEVEL = 771.1

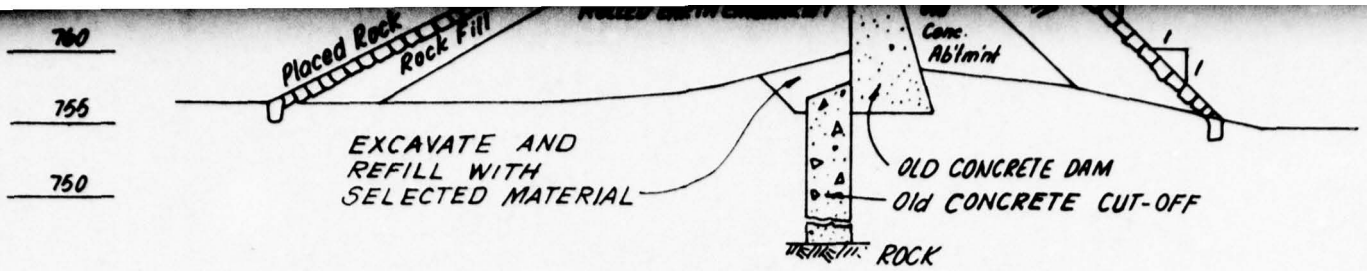


MAIN DAM

PLAN

0 10 20 30 40 50 60 70 80

1



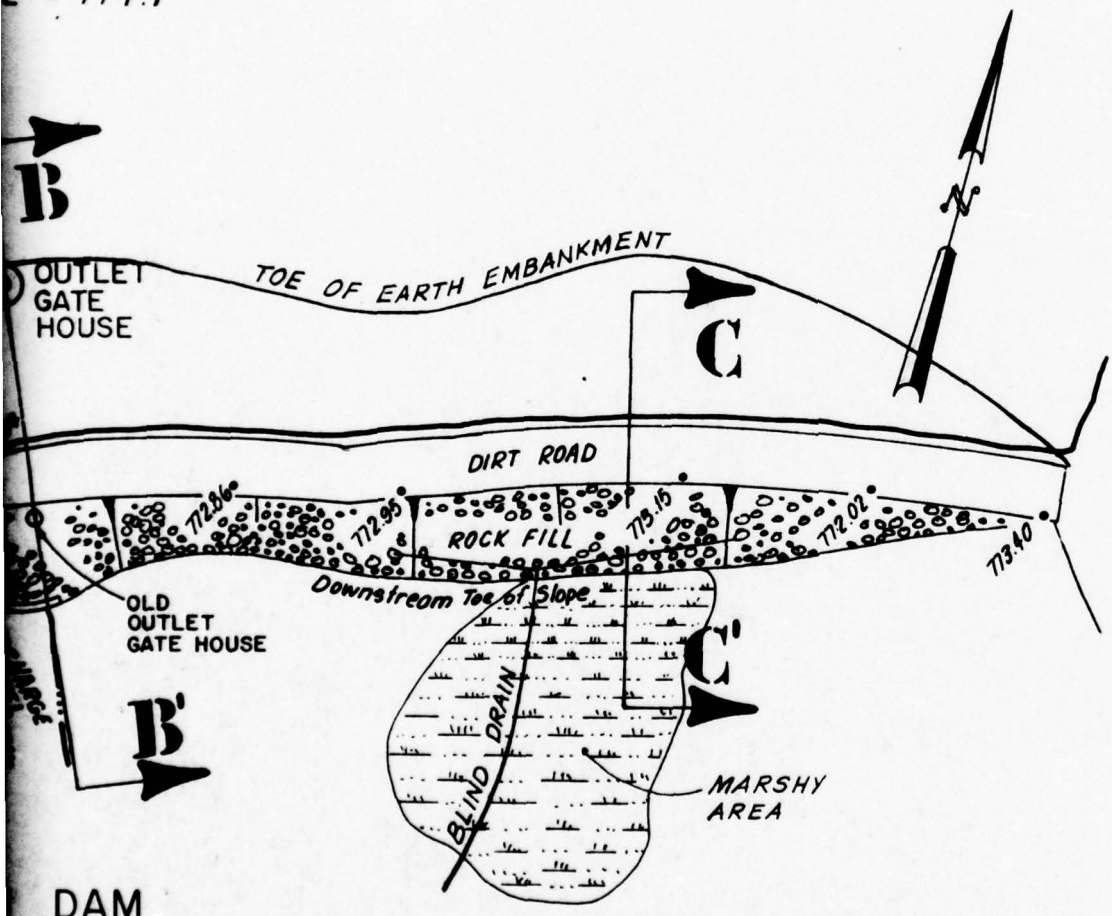
MAIN DAM-CROSS SECTION

SECTION C-C'

0 5 10 15 20 25 ft

RESERVOIR

L = 771.1

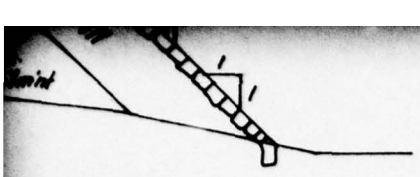


DAM

AN

60 70 80 90 100 ft

REFERENCE:
PLAN SHOWING REINFOR
OF THE CONCRETE DAM O
APSHAWA COMPANY, DAT
10 MAY 1912



760

755

760

CONCRETE DAM
CONCRETE CUT-OFF

SECTION
C-C'

25 ft

4

REFERENCE:
PLAN SHOWING REINFORCEMENT OF THE CONCRETE DAM OF THE APSHAWA COMPANY, DATED 10 MAY 1912

DATE	DESCRIPTION	NO.
REVISIONS		

PROJECT

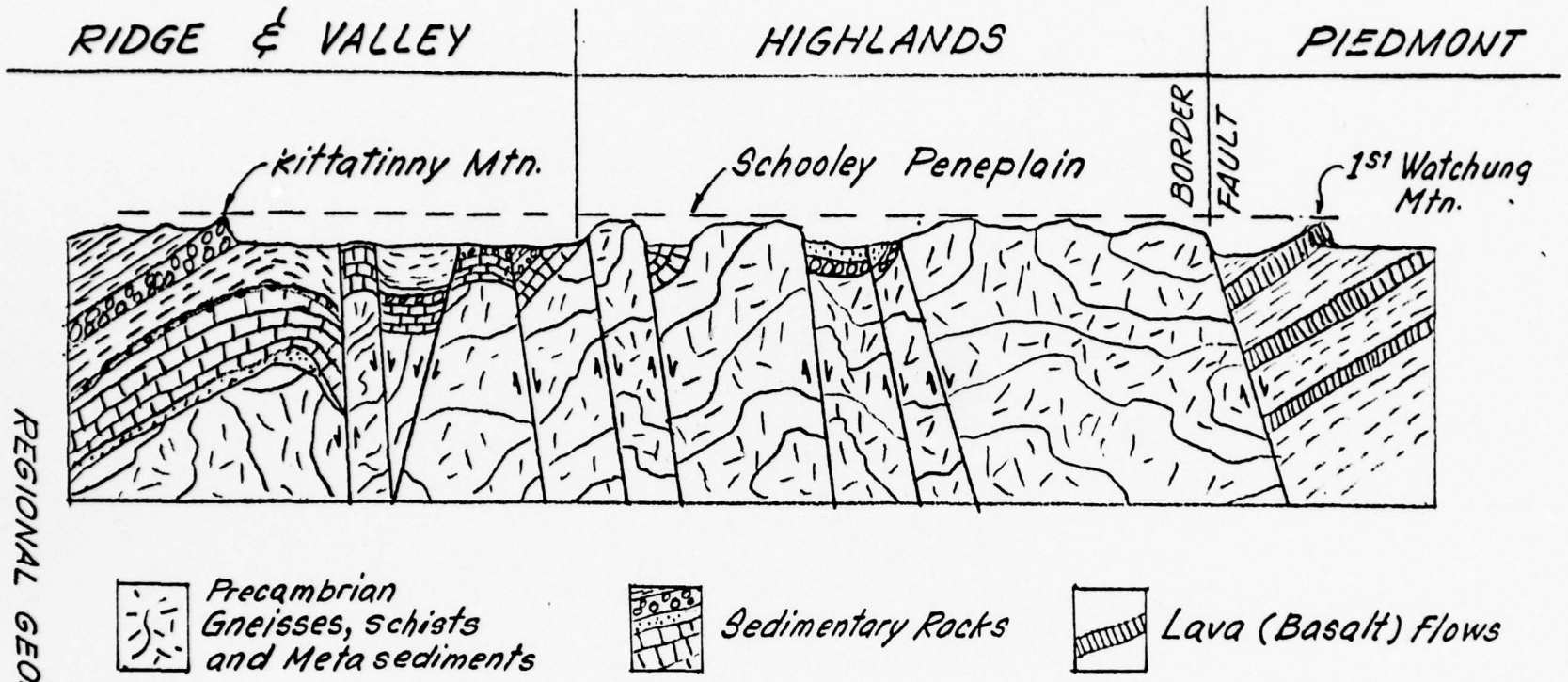
PHASE I
INSPECTION & EVALUATION of NEW JERSEY DAMS

APSHAWA DAMS
JUNE 1978
MAIN DAM, FED. ID. No. NJ 00318
AUX. DAM, FED. ID. No. NJ 00557

JOB NO.	J783
DATE	5 July 1978
SCALE	as noted
DRN. BY	JMR
CHKD. BY	DJL

FIG. 2

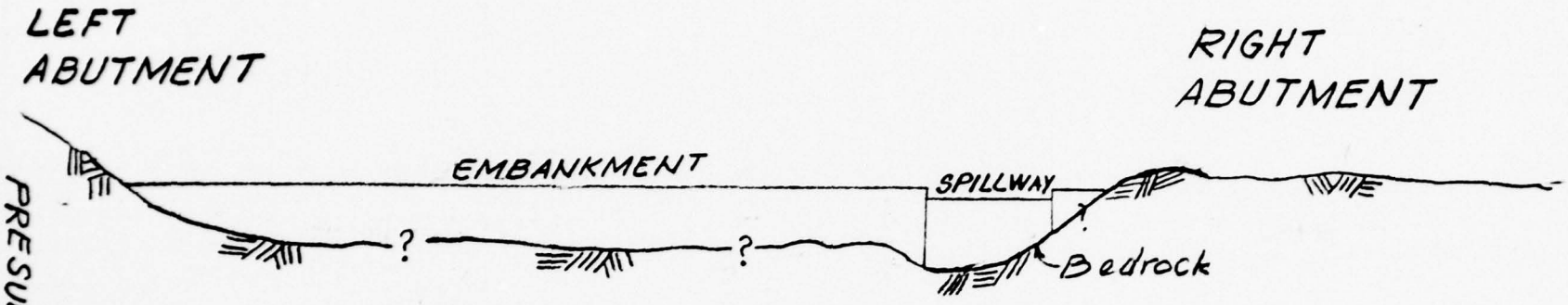
9



Schematic Cross-section of New Jersey Highlands Physiographic Province (After Wolfe, 1977)

REGIONAL GEOLOGIC FEATURES

Fig 3



DIAGRAMMATIC SKETCH
APSHAWA DAM
(NO SCALE)

PRESUMED SITE GEOLOGIC FEATURES

Fig 4

APPENDIX 1

CHECK LIST

VISUAL INSPECTION

APSHAWA DAMS

Check List
Visual Inspection
Phase 1

Name Dam Apshawa Dam County Passaic State New Jersey Coordinators NJ DEP

Date(s) Inspection 7, 12, 19, 27 June 1978 Weather Sunny Temperature 70 - 80° F

Pool Elevation at Time of Inspection 771.1 M.S.L. Tailwater at Time of Inspection 754 M.S.L.

Inspection Personnel:

D. Leary -7,12 & 19 June D. Lachel - 27 June

C. Campbell - 12 June

A. Puyo - 19 June

D. Leary Recorder

APSHAWA DAMS

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SEEPAGE	Seepage at downstream left embankment of main dam and downstream of auxilliary dam. Marshy areas at both locations.	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	Not observable.	
DRAINS	None observed.	
WATER PASSAGES	Free-fall spillway	
FOUNDATION	Natural rock at spillway and piers.	

APSHAWA DAMS

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBERSVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	Spalling at downstream face of spillway.	
STRUCTURAL CRACKING	Crack in concrete core at left abutment of spillway sidewall.	
VERTICAL AND HORIZONTAL ALIGNMENT	Appeared good from observation of embankment crest.	
MONOLITH JOINTS	None Observed except at central pier of spillway	
CONSTRUCTION JOINTS	Weathering at central pier of spillway along interface of concrete lifts. Horizontal surface cracks in sidewalls.	

APSHAWA DAMS

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None Observed	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None Observed	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	Erosion of embankment crest and downstream rockfill at left spillway abutment by overtopping.	
VERTICAL AND HORIZONTAL ALINEMENT OF THE CREST	Generally good but being worn down from use as a foot path.	
RIPRAP FAILURES	At spillway left side wall embankment abutment. Downstream rip rap has failed near crest of embankment.	

APSHAWA DAMS

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SEEPAGE	Marshy area and seepage downstream of auxiliary dike.	
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Erosion by overtopping - removal of about 3 ft of crest and surface of rip-rap for approximately 8 ft of downstream slope below crest at left spillway embankment abutment.	
ANY NOTICEABLE SEEPAGE	Seepage downstream of left embankment.	Probably through cracks in rock or clogged drains.
STAFF GAGE AND RECORDER	None observed.	
DRAINS	None observed. Blind stone drains are reported on drawing.	Locate and check blind drains of the main dam - clean them or put an additional one or pipe.

APSHAWA DAMS

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	None observed	
INTAKE STRUCTURE	Outlet gate house in reservoir no cover and masonry work has deteriorated.	
OUTLET STRUCTURE	14 in. dia cast iron pipe and valve flowing at 25 g/m. Flow may be restricted. About 1/3 cross section flowing.	
OUTLET CHANNEL	Rock bottom with small boulders and some debris	
EMERGENCY GATE	Outlet gate pit partially open, no access to pit because of debris	Should be cleaned and valve checked

APSHAWA DAMS

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	General condition is good. Spillway crest is not level with 2 to 3 inches difference. Left side is higher than right side.	
APPROACH CHANNEL	None observed	
DISCHARGE CHANNEL	Rocks small boulders and debris in stream entering Apshawa Brook	
BRIDGE AND PIERS	Buttress pier at center and abutment wall at ends of spillway. Pier has erosion of concrete at construction lifts. Concrete of sidewalk has deteriorated, spalled and cracked horizontally at construction joints.	

APSHAWA DAMS

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	No signs of instability observed	
SEDIMENTATION	Some sedementation at upstream face of dam	Should be measured

APSHAWA DAMS

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Obstruction by rock and debris	Not considered significant
SLOPES	Channel side slopes are variable; 10 to 20 hor to 1 vert	
APPROXIMATE NO. OF HOMES AND POPULATION	Butler is identified as nearest D/S City with population of 7,051 on N.J. Dam Inventory prepared under PL 92-367.	Apshawa Brook passes under Route 23.

APPENDIX 2

PHOTOGRAPHS

APSHAWA DAMS

Spillway, Left Sidewall and sloughing of upstream riprap. 19 June 1978

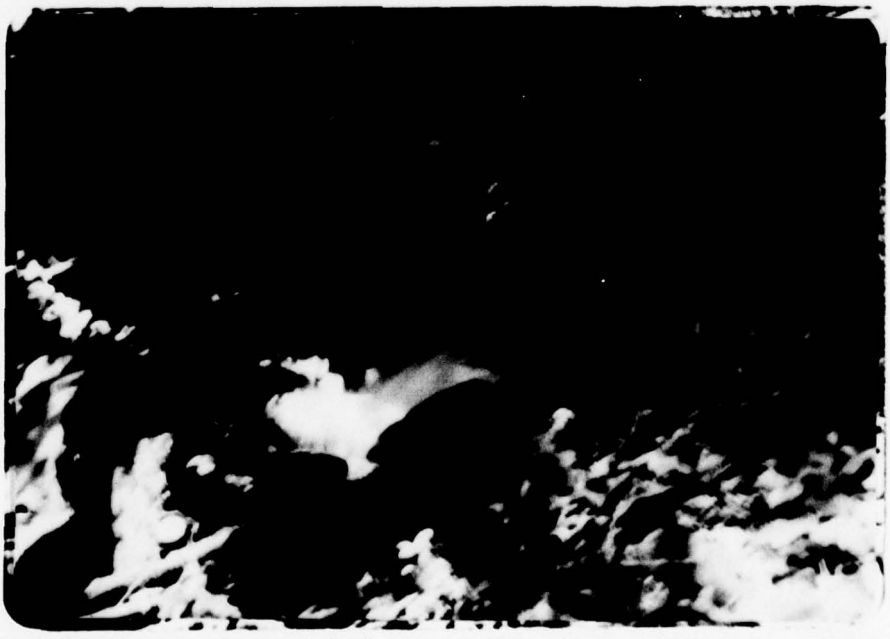
Spillway side wall looking east. Note spalling of concrete and downstream riprap. 19 June 1978

Outlet gate house and left side of spillway. 19 June 1978

Outlet gate house without cover. 19 June 1978

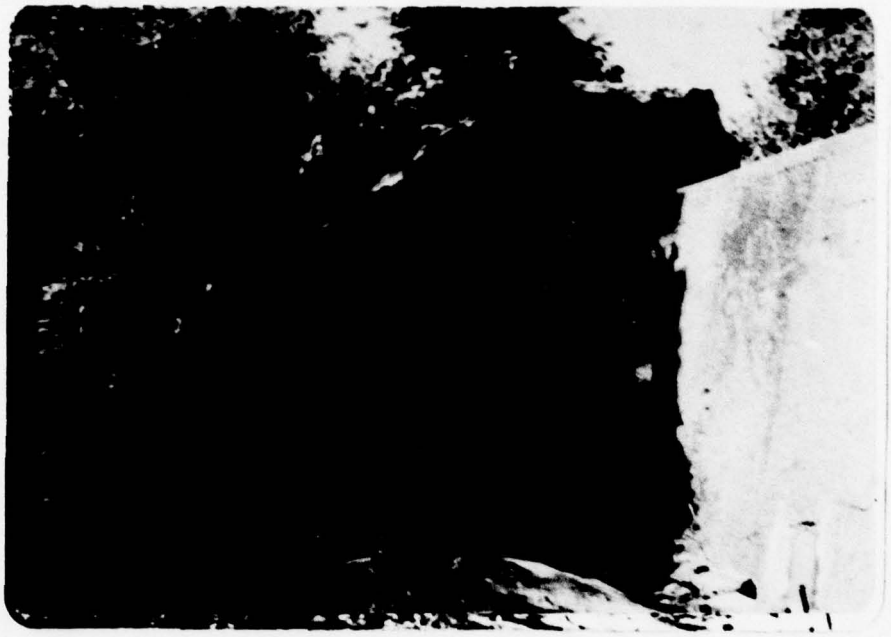
APSHAWA LAKE DAM

Downstream outlet gate house 19 June 1978
at left embankment.



Discharge from 14 inch c.l. pipe 19 June 1978
from downstream outlet gate house.

APSHAWA LAKE DAM



Spillway right sidewall. 19 June 1978
Note foundation rock in
foreground.

Spillway left sidewall. 19 June 1978
Note disturbance of riprap.

Erosion and removal of riprap at spillway and left sidewall abutment. 19 June 1978

Erosion of riprap at spillway and left sidewall abutment. 19 June 1978

Erosion at spillway left sidewall. 19 June 1978

Erosion of riprap and earth at left spillway sidewall abutment. 19 June 1978

Foundation rock and seepage at downstream right corner of spillway. 19 June 1978

Upstream corner of spillway left sidewall. Note cracks in old concrete dam serving as concrete core in present dam. 19 June 1978

APSHAWA LAKE DAM

Central buttress pier at downstream face of spillway. 19 June 1978

Central pier at spillway. Note horizontal grooves where concrete lifts were placed. 19 June 1978

Foundation rock at base of central pier at downstream face of spillway. 19 June 1978

Spillway discharge channel looking downstream. 19 June 1978

Top and downstream riprapped face of auxiliary dam. 19 June 1978

Wet and marshy area downstream of auxiliary dam. 19 June 1978

APPENDIX 3

HYDROLOGIC COMPUTATIONS

APSHAWA DAMS

LANGAN ENGINEERING ASSOCIATES, INC.

HYDROLOGIC CALCULATIONS
APSHAWA DAM

1. Location — Passaic Co N.J. within Passaic River Basin
2. Drainage area — 790 acres or 1.23 Sq mi
3. Lake area — 43 acres
4. Classification
   Size - Small < 1000 ac ft storage
   Hazard - Significant
5. Spillway Design Flood — 100 yr to ½ PMF

C. Calculate — ½ PMF

1. Apshawa located in Zone 6
   PMP = 22.5 inches (200 sq mi 24 hr)
2. PMP adjustment factors

Duration	% of 24 hr	Reduction Factor *
0-6	112	
0-12	123	.8 all hrs
0-24	132	

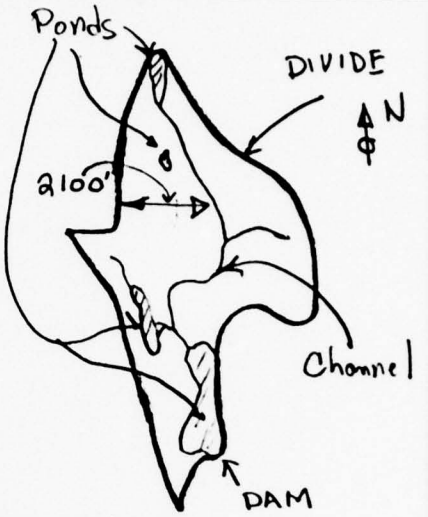
* p. 48 "Small Dams"

BY JC DATE ____ Apshawa Dam JOB NO. J-783
CKD GED DATE 29 Aug SHEET NO. 1 OF 14

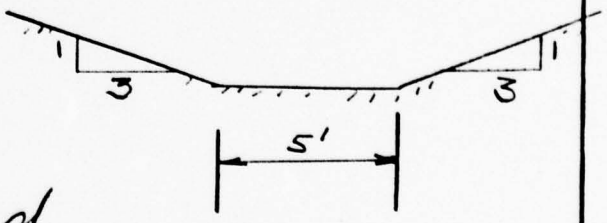
LANGAN ENGINEERING ASSOCIATES, INC.

DETERMINE TIME OF CONCENTRATION

There is a stream running through the apshawa water shed



From a site inspection the ground cover is "Forest with Heavy Ground Litter & Meadow" & the stream has irregular side slopes and bottom & the cross section is filled with large growth ∴ CN=60
∴ take Mannings $n = 0.06$.
The cross section of the stream will be approximated as



Slope of the stream
$S_o = .029$

Slope of the north east portion of the water shed
$S = 7\%$

From SCS Tech Rel #55 determine Tc

BY JC DATE 8/25 Apshawa JOB NO. J-783
CKD ED DATE 8/30 SHEET NO. 2 OF 14

≙ Assume overland flow from A to B and stream flow from B-C

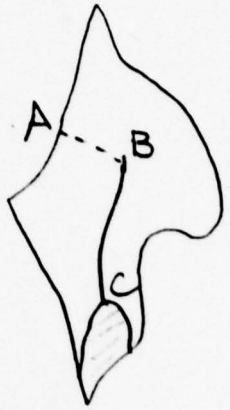


Fig 3-1, vel = 0.67 fps

$$T_{AB} = \frac{\text{length}}{\text{vel.}} = \frac{2100}{(.67)(3600)} = 0.87 \text{ hr}$$

We estimate that an approximate average value of Q in the stream during the T_c; = 2000 cfs

$$Q = \frac{1.49}{n} A R^{2/3} S_o^{1/2}$$

$$2000 = \frac{1.49}{.06} (A R^{2/3}) (.029)^{1/2}$$

$$A R^{2/3} = 473$$

∴ depth of flow ≅ 7'

$$\text{Area of flow} = 5(7) + 2\left(\frac{3(5)(5)}{2}\right) = 110 \text{ ft}^2$$

$$T_{BC} = \frac{L_{BC}}{v} = \frac{4500}{\frac{2000}{110}(3600)} = 0.07 \text{ hr}$$

$$T_c = T_{AB} + T_{BC} = 0.87 + 0.07 = \underline{0.94 \text{ hr}}$$

B Determine T_c from Fig 3-3

Avg slope of the water shed = 4%

l = Greatest flow length $\approx$ 6000 ft

$\therefore$ Lag Time = 1.2 hr

& $T_c = \frac{1.2}{0.6} = \underline{2.0 \text{ hr}}$

Because the apshawa water shed is very steep with a network of streams take

T_c = 1 hour

DETERMINE TIME OF PEAK

$T_p = \frac{D}{2} + 0.6\, T_c$

Take D = 15 min

$T_p = \frac{.25}{2} + .6\,(1) = 0.725$

Take

T_p = 0.75 hours

UNIT HYDROGRAPH

Take q_p from SCS formula

$q_p = \frac{484A}{TP} = \frac{484(1.23)}{0.75} = \underline{794}$ cfs

LANGAN ENGINEERING ASSOCIATES, INC.

A curvilinear hydrograph may be constructed from values of q_p and T_p by using ratios tabulated in "Design of Small Dams" pg 74, Take the Time increment = D

HOURS	T/T_p	q/q_p	UNIT HYDROGRAPH q (cfs)
.25	.33	0.18	143
.50	.66	0.74	588
.75	1.00	1.00	794
1.00	1.33	0.83	659
1.25	1.66	0.51	405
1.50	2.00	0.32	254
1.75	2.33	0.20	159
2.00	2.66	0.12	95
2.25	3.00	0.075	60
2.50	3.33	0.044	35
2.75	3.66	0.024	19
3.00	4.00	0.018	14
3.25	4.33	0.016	12

$\Sigma q = 3237$ cfs

Area Under Unitgraph $= \frac{3237(.25)(3600)(12)}{789.7(43560} = 1.02''$

BY JC DATE 8/25 Ajoshawa JOB NO. J-783

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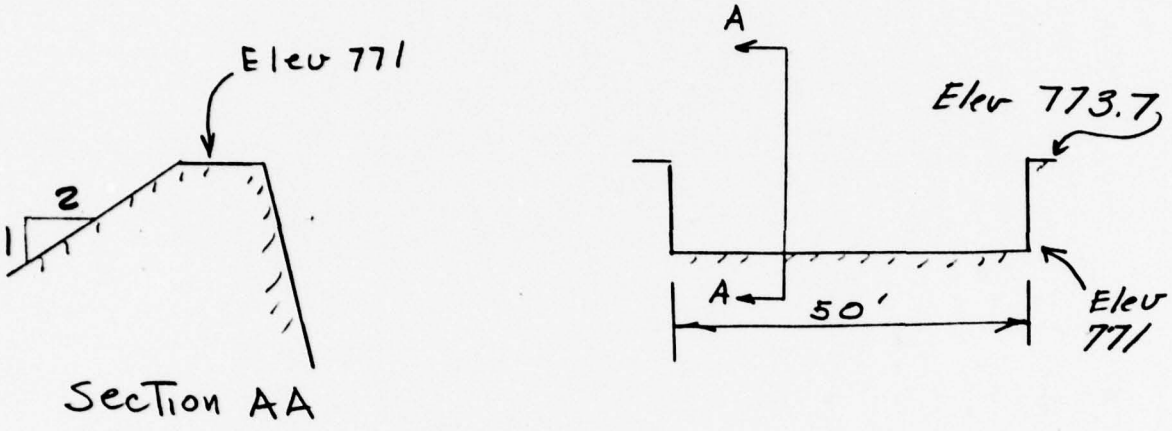
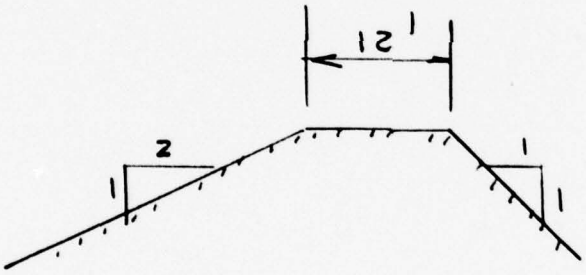
LANGAN ENGINEERING ASSOCIATES, INC.

Spillway Capacity





Typical cross-section through the Main Dam

Note! - the Auxiliary Dam has a similar cross section

∴ in the computation of Q, the dam wall and auxiliary dam will be taken together.

BY JC DATE 8/25 Apshawa JOB NO. J783

CKD GED DATE 8/30 SHEET NO. 6 OF 14

LANGAN ENGINEERING ASSOCIATES, INC.

$$Q = C L H^{3/2}$$

From "King and Brater" pg 5-50 Table 5-11

$C_{spillway} = 3.1$, $L = 50'$

pg 5-49 Table 5-9

$C_{Res} = 3.0$

Low Point of the Reservoir wall is 772.02 ←

∴ take Low Point = 772'

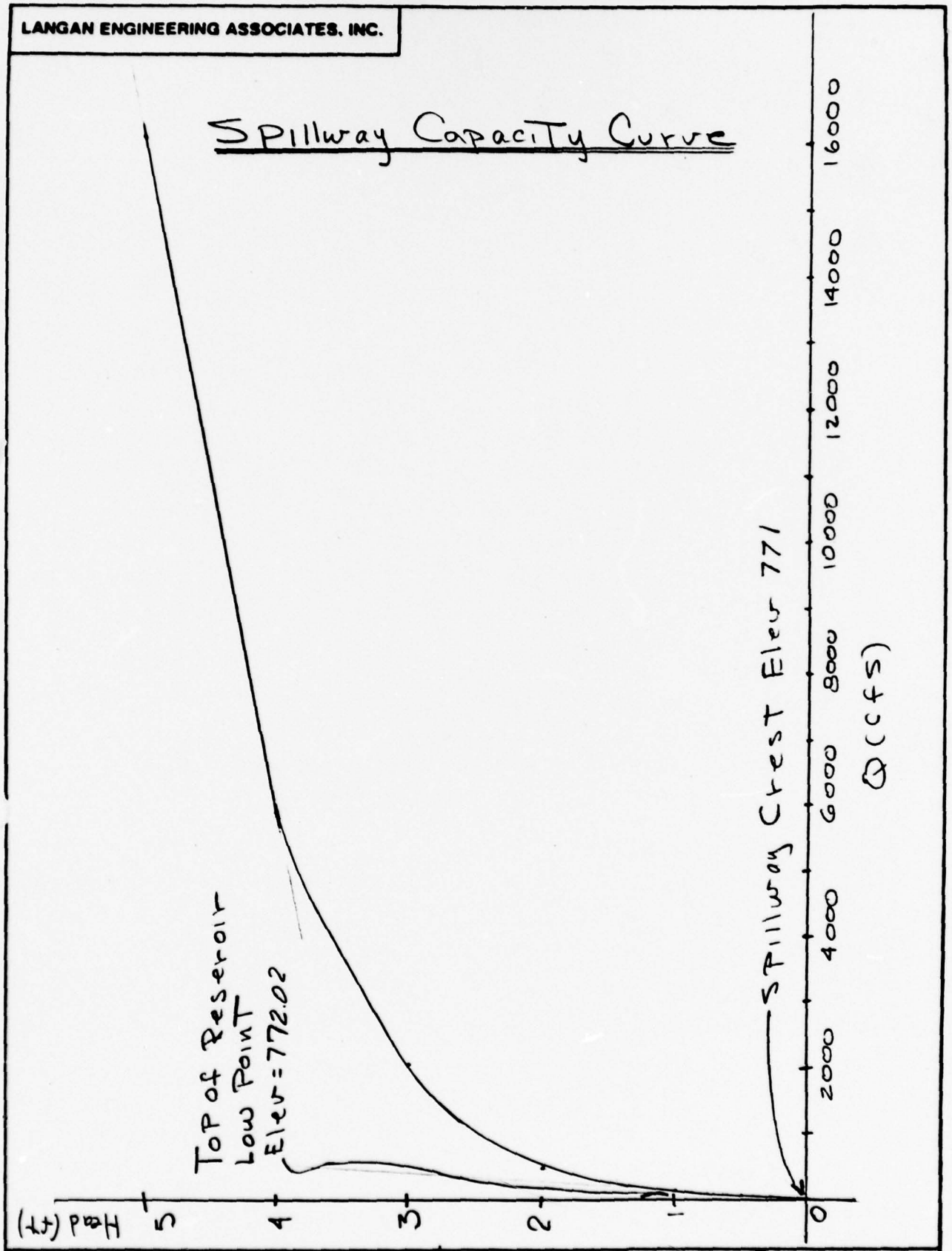
Elev ft	Spillway H (ft)	Spillway Q_S (cfs)	Reservoir + Auxil. spill H (ft)	Reservoir + Auxil. spill L (ft)	Reservoir + Auxil. spill Q_r cfs	Q TOTAL $Q_c + Q_r$ cfs
771	0					0
771.5	.5	55				55
772	1	155	0			155
773	2	438	1	20	60	498
774	3	805	2	150	1273	2078
775	4	1240	3	300	4676	5916
776	5	1733	4	600	14400	16133

BY JC DATE 8/25 Apshawa JOB NO. J-783

CKD [illegible] DATE 8/30 SHEET NO. 7 OF 14

LANGAN ENGINEERING ASSOCIATES, INC.

Spillway Capacity Curve



BY JC DATE 8/25 Apshawa JOB NO. J-783

CHECKED DATE 8/30 SHEET NO. 8 OF 14

LANGAN ENGINEERING ASSOCIATES, INC.

Reservoir Storage Capacity

Assume a linear distribution for the increase of the area with elevation. Start at a zero storage at the crest of the spillway

Lake area ≅ 43 ac Elev ≈ 771

Area Elev 780' ≅ 52 ac

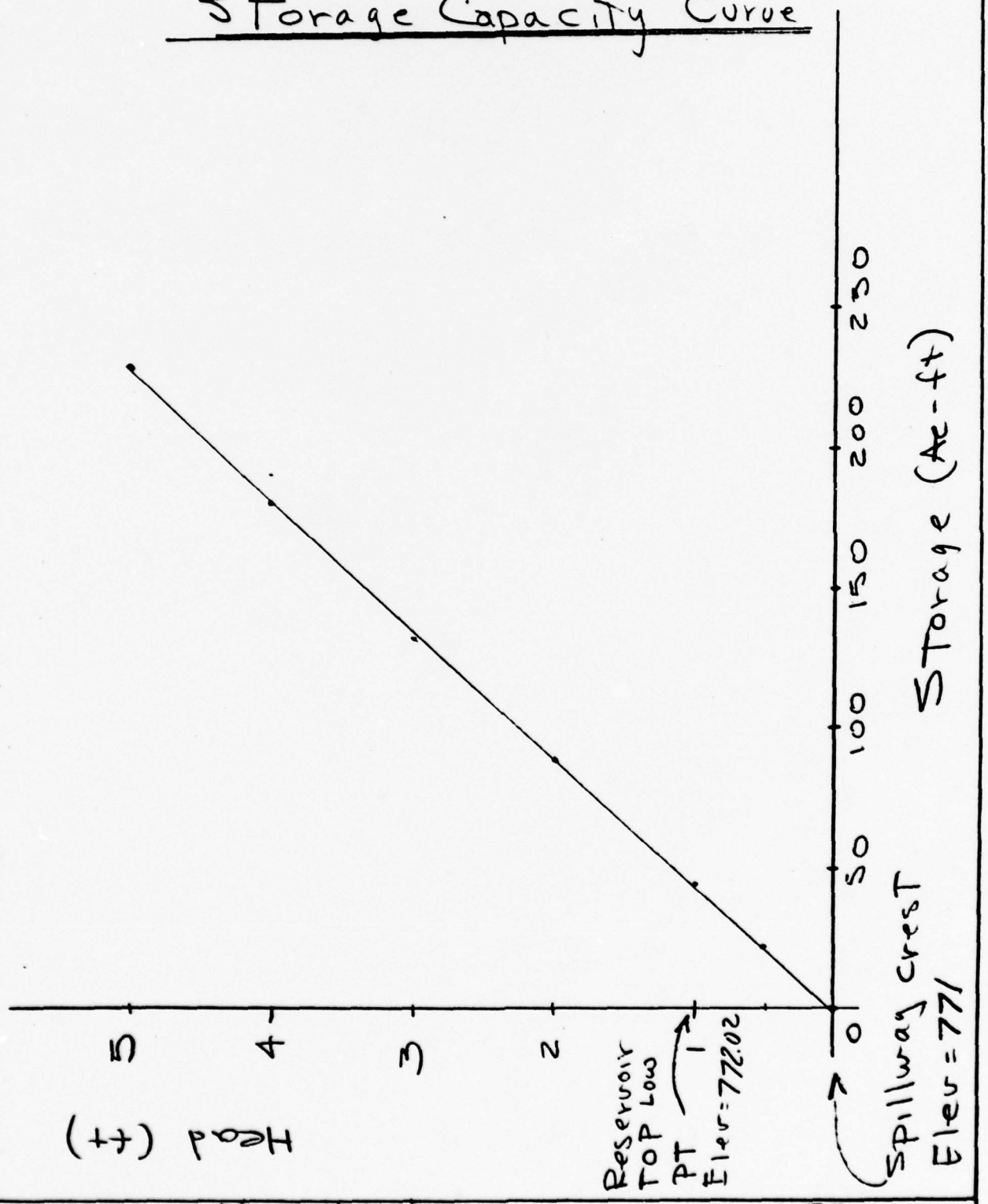
Elev (ft)	H (ft)	Area (Acres)	Avg Area (Acres)	Storage (Ac-ft)
771	0	43		
			43.25	21.6
771.5	.5	43.5		
			43.5	43.5
772	1	44		
			44	88
773	2	45		
			44.5	131
774	3	46		
			45	180
775	4	47		
			45.5	228
776	5	48		

BY JC DATE 8/25 Apshawa JOB NO. J-783

CKD GED DATE 8/30 SHEET NO. 9 OF 14

LANGAN ENGINEERING ASSOCIATES, INC.

Storage Capacity Curve



BY JC DATE 8/25 Apshawa JOB NO. J-783

CKD GED DATE 8/30 SHEET NO. 10 OF 14

Elev	H ft	Q cfs	Storage
771	0	0	0
771.5	0.5	55	21.6
772.0	1	155	43.5
773	2	498	88
774	3	2078	131
775	4	5916	180
776	5	16133	228

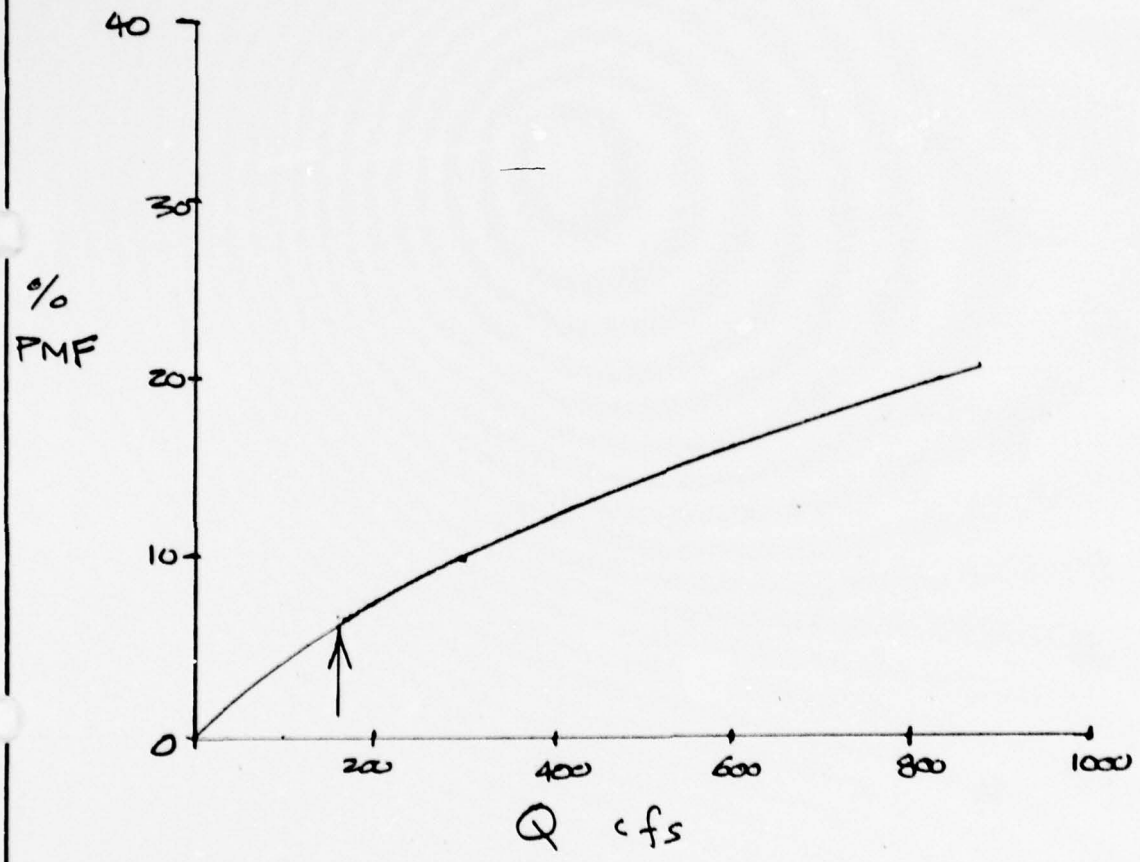
HYDROGRAPH & FLOOD ROUTING

1. Hydrograph and flood routing determined HEC-1
2. ½ PMF = 2552 cfs (routed to 2433 cfs)
3. Routing indicates dam will overtop for ½ PMF by approximately 1 to 2 ft.

LANGAN ENGINEERING ASSOCIATES, INC.

OVERTOPPING POTENTIAL

1. Route various % PMF
2. Plot % PMF vs outflow



3. Dam begins to overtop at el 772 with Q = 155 cfs
   ∴ dam can pass approx. 6% of PMF

BY GED DATE 8/30 Apshawa JOB NO. J-783
CKD GED DATE 8/30 SHEET NO. 12 OF 14

LANGAN ENGINEERING ASSOCIATES, INC.

RESERVOIR DRAWDOWN

1. Assume outlet control - 14" CIP

$$H = \left(1 + K_e + K_v + K_p L\right) \frac{V^2}{2g}$$

$$= 1 + .23 + .2 + \frac{5087\, n^2 L}{14^{1.33}} \frac{Q^2}{2g \frac{\pi D^2}{4}}$$

$$= \left[1 + .23 + .2 + .022(75)\right] \frac{Q}{2g\pi \frac{(1.16)^2}{4}}$$

$$K_p = \frac{5087\, n^2}{d^{4/3}}$$

$$K_p = \frac{(5087)(.012)^2}{14^{4/3}}$$

$$K_p = .022$$

$$H = \left[1.43 + 1.65\right] \frac{Q^2}{68.8} = \frac{3.08}{68.8} Q^2 = .045 Q^2$$

$$Q = \frac{H}{\sqrt{.045}} = 4.72\, H^{1/2}$$

H	2	4	6	8	10	12	14	16	18
Q	6.7	9.4	11.6	13.4	15	16.4	17.6	18.8	20

2. Storage between spillway crest and bottom is equal to 750 acft and area varies linearly with depth ∴ A(18) =

Area per foot = $\left(\frac{43+x}{2}\right) 18 = 750$ $\quad x = 40.3$ (area at bottom)

∴ volume is approx linear with depth @ 43 acft per ft

3. Inflow assumed to 2 cfs / sq mi or 2.5 cfs

BY CED	DATE 7/21/78	Apshawa Dam	JOB NO. J-783
CK'D CED	DATE 8/30/78		SHEET NO. 13 OF 13

LANGAN ENGINEERING ASSOCIATES, INC.

BY FED DATE
CKD FED DATE 8/31/78

Apshere

JOB NO. J-783

SHEET NO. 14 OF 14

head	Qout	Qout avg	Qnet*	storage	$\Delta t_{a,}$	$\Sigma \Delta t$ hr
18	20					
16	18.8	19.4	16.9	86	61	
12	17.6	18.8	16.3	86	63.8	124
14	16.4	17.0	14.5	86	71.7	195.7
10	15.0	15.7	13.2	86	78.8	274
8	13.4	14.2	11.7	86	88.94	364 (15 days)
6	11.6	12.5	10.0	86	104.	467
4	9.4	10.5	8.0	86	130	597
2	6.7	8.05	5.5	86	189	786 (32day)

* $Q_{net} = Q_{out\,avg} - 2.5$ cfs


Echo
Echo Lake
Macopin
St. Joseph
High Crest Lake
Henion Pond

MAP SOURCE: USGS
NEWFOUNDLAND & WANAQUE
SCALE: 1" = 2000'

DRAINAGE BASIN
APSHAWA

2

LANGAN ENGINEERING ASSOCIATES, INC.

CONSULTING ENGINEERS
970 CLIFTON AVE. CLIFTON, N.J. 07013 201 472-3300

HEC-1 OUTPUT

APSHAWA DAMS

```
 listcf apsl0 'breakdown'-

APS10      12:21 AUG 30,'78

AMDS09 JOB 2890 (LANG0436) IN BREAKDOWN
 CDC1B          LANG0436      2890      PT06P001        11.20.20  30 AUG 78        GED                    GED

******************************
HEC-1 VERSION DATED JAN 1973
UPDATED AUG 74
CHANGE NO. 01
******************************

******************************
HEC-1 VERSION DATED JAN 1973
UPDATED AUG 74
CHANGE NO. 01
******************************
                    APSHAWA DAM
                    DETERMINE INFLOW HYDROGRAPH AND ROUTE % PMF-APSHAWA DAM
                    N.J. DAM INSPECTION

                                        JOB SPECIFICATION
                          NQ   NHR  NMIN  IDAY   IHR  IMIN METRC  IPLT  IPRT NSTAN
                         100     0    15     0     0     0     0     0     4     0
                                                JOPER      NWT
                                                    5        0


                                    MULTI-PLAN ANALYSES TO BE PERFORMED
                                        NPLAN% 1 NRTIO% 6 LRTIO% 1
                        RTIOS%   1.00   0.50   0.40   0.30   0.20   0.10


**********          **********          **********          **********          **********

                                    SUB-AREA RUNOFF COMPUTATION

                    COMPUTE HYDROGRAPH
                                ISTAQ   ICOMP   IECON   ITAPE   JPLT   JPRT   INAME
                                    1       0       0       0      0      0       1

                                                HYDROGRAPH DATA
                    IHYDG    IUNG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
                        1      -1    1.23     0.0    1.23    0.00     0.0       0       0       0

                                                PRECIP DATA
                             SPFE     PMS      R6      R12      R24      R48      R72      R96
                                                22.5     112      123      132        0
```

LOSS DATA

STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0.0	0.0	1.00	0.0	0.0	1.00	1.00	0.20	0.0	0.0

RECESSION DATA

STRTQ$ -2.00 QRCSN$ 0.0 RTIOR$ 1.00

END-OF-PERIOD FLOW

	TIME	RAIN	EXCS	COMP Q
SUM		23.76	19.55	63677.

•••••••••• •••••••••• •••••••••• •••••••••• ••••••••••

HYDROGRAPH ROUTING

ROUTING COMPUTATIONS

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
1	1	0	0	0	0	1

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME
0.0	0.0	0.0	1	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA
1	0	0	0.0	0.0	0.0	0.

STORAGE$	22.	44.	88.	131.	180.	228.	0.	0.	0.	0.
OUTFLOW$	55.	155.	490.	2070.	5916.	16133.	0.	0.	0.	0.

•••••••••• •••••••••• •••••••••• •••••••••• ••••••••••

PEAK FLOW SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS

			RATIOS APPLIED TO FLOWS					
OPERATION	STATION	PLAN	1.00	0.50	0.40	0.30	0.20	0.10
HYDROGRAPH AT	1	1	5104.	2552.	2042.	1531.	1021.	510.
		2	0.	0.	0.	0.	0.	0.
ROUTED TO	1	1	4896.	2433.	1873.	1388.	829.	294.
		2	0.	0.	0.	0.	0.	0.

```
 listcf aps20 'breakdown'-

APS20      12:27 AUG 30,'78

AMDS09 JOB 1839 (LANG0316) IN BREAKDOWN
 CDC1B          LANG0316     1839      FT06F001        9.49.17  30 AUG 78       GED                          GED

******************************
HEC-1 VERSION DATED JAN 1973
UPDATED AUG 74
CHANGE NO. 01
******************************

******************************
HEC-1 VERSION DATED JAN 1973
UPDATED AUG 74
CHANGE NO. 01
******************************
                    APSHAMA DAM
                    DETERMINE INFLOW HYDROGRAPH AND ROUTE PMF-APSHAMA DAM
                    W.J. DAM INSPECTION

                                        JOB SPECIFICATION
                          NQ   NHR  NMIN  IDAY   IHR  IMIN METRC  IPLT  IPRT NSTAN
                         100     0    15     0     0     0     0     0     0     0
                                             JOPER      NWT
                                                 3        0


**********          **********          **********          **********          **********

                                    SUB-AREA RUNOFF COMPUTATION

                  COMPUTE HYDROGRAPH
                              ISTAQ   ICOMP   IECON   ITAPE   JPLT   JPRT  INAME
                                  1       0       0       0      0      0      1

                                              HYDROGRAPH DATA
                 IHYDG    IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
                     1      -1    1.23     0.0    1.23    0.80     0.0       0       0       0

                                              PRECIP DATA
                           SPFE     PMS      R6     R12     R24     R48     R72     R96
                           0.0    22.50  112.00  123.00  132.00     0.0     0.0     0.0

                                              LOSS DATA
                 STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
```

0.0 0.0 1.00 0.0 0.0 1.00 1.00 0.20 0.0 0.0

GIVEN UNIT GRAPH, HUNGQ$ 13

143. 588. 794. 659. 405. 254. 159. 95. 60. 35.
19. 14. 12.

UNIT GRAPH TOTALS 3237. CFS OR 1.02 INCHES OVER THE AREA

RECESSION DATA

STRTQ$ -2.00 QRCSN$ 0.0 RTIOR$ 1.00

END-OF-PERIOD FLOW

TIME	RAIN	EXCS	COMP Q
1	0.03	0.00	2.
2	0.03	0.00	2.
3	0.03	0.00	2.
4	0.03	0.00	2.
5	0.03	0.00	2.
6	0.03	0.00	2.
7	0.03	0.00	2.
8	0.03	0.00	2.
9	0.03	0.00	2.
10	0.03	0.00	2.
11	0.03	0.00	2.
12	0.03	0.00	2.
13	0.03	0.00	2.
14	0.03	0.00	2.
15	0.03	0.00	2.
16	0.03	0.00	2.
17	0.03	0.00	2.
18	0.03	0.00	2.
19	0.03	0.00	2.
20	0.03	0.00	2.
21	0.03	0.00	2.
22	0.03	0.00	2.
23	0.03	0.00	2.
24	0.03	0.00	2.
25	0.08	0.00	2.
26	0.08	0.00	2.
27	0.08	0.00	2.
28	0.08	0.00	2.
29	0.08	0.02	6.
30	0.08	0.03	21.
31	0.08	0.03	45.
32	0.08	0.03	68.
33	0.08	0.03	83.
34	0.08	0.03	93.
35	0.08	0.03	99.
36	0.08	0.03	102.
37	0.08	0.03	105.
38	0.08	0.03	106.
39	0.08	0.03	107.

40	0.08	0.03	107.
41	0.08	0.03	108.
42	0.08	0.03	108.
43	0.08	0.03	108.
44	0.08	0.03	108.
45	0.08	0.03	108.
46	0.08	0.03	108.
47	0.08	0.03	108.
48	0.08	0.03	108.
49	0.50	0.45	168.
50	0.50	0.45	416.
51	0.50	0.45	750.
52	0.50	0.45	1028.
53	0.60	0.55	1213.
54	0.60	0.55	1380.
55	0.60	0.55	1527.
56	0.60	0.55	1633.
57	0.76	0.71	1721.
58	0.76	0.71	1850.
59	0.76	0.71	1994.
60	0.76	0.71	2109.
61	1.92	1.87	2347.
62	1.92	1.87	3071.
63	1.92	1.87	4017.
64	1.92	1.87	4797.
65	0.71	0.66	5104.
66	0.71	0.66	4692.
67	0.71	0.66	3919.
68	0.71	0.66	3234.
69	0.55	0.50	2794.
70	0.55	0.50	2439.
71	0.55	0.50	2148.
72	0.55	0.50	1950.
73	0.04	0.00	1758.
74	0.04	0.00	1380.
75	0.04	0.00	933.
76	0.04	0.00	569.
77	0.04	0.00	341.
78	0.04	0.00	208.
79	0.04	0.00	125.
80	0.04	0.00	75.
81	0.04	0.00	43.
82	0.04	0.00	25.
83	0.04	0.00	16.
84	0.04	0.00	9.
85	0.04	0.00	2.
86	0.04	0.00	2.
87	0.04	0.00	2.
88	0.04	0.00	2.
89	0.04	0.00	2.
90	0.04	0.00	2.

91	0.04	0.00	2.
92	0.04	0.00	2.
93	0.04	0.00	2.
94	0.04	0.00	2.
95	0.04	0.00	2.
96	0.04	0.00	2.
97	0.0	0.0	2.
98	0.0	0.0	2.
99	0.0	0.0	2.
100	0.0	0.0	2.
SUM	23.76	19.55	63677.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	5104.	2460.	663.	637.	63695.
INCHES		18.60	20.07	20.07	20.07
AC-FT		1220.	1316.	1317.	1317.

8

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

ROUTING COMPUTATIONS

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
1	1	0	0	0	0	1

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME
0.0	0.0	0.0	1	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA
1	0	0	0.0	0.0	0.0	0.

STORAGE#	22.	44.	88.	131.	180.	228.	0.	0.	0.	0.
OUTFLOW#	55.	155.	498.	2078.	5916.	16133.	0.	0.	0.	0.

TIME	EOP STOR	AVG IN	EOP OUT
1	0.	2.	0.
2	0.	2.	0.
3	0.	2.	0.
4	0.	2.	0.
5	0.	2.	0.
6	0.	2.	0.
7	0.	2.	0.
8	0.	2.	0.
9	0.	2.	0.
10	1.	2.	0.
11	1.	2.	0.
12	1.	2.	0.
13	1.	2.	0.

14	1.	2.	0.
15	1.	2.	0.
16	1.	2.	0.
17	1.	2.	0.
18	1.	2.	0.
19	1.	2.	0.
20	1.	2.	0.
21	1.	2.	0.
22	1.	2.	0.
23	1.	2.	0.
24	1.	2.	0.
25	1.	2.	0.
26	1.	2.	0.
27	1.	2.	0.
28	1.	2.	0.
29	2.	4.	0.
30	2.	13.	0.
31	2.	33.	0.
32	4.	56.	0.
33	5.	75.	0.
34	7.	88.	0.
35	9.	96.	0.
36	11.	100.	5.
37	13.	103.	14.
38	15.	105.	22.
39	16.	106.	30.
40	18.	107.	37.
41	19.	107.	43.
42	21.	108.	49.
43	22.	108.	54.
44	23.	108.	59.
45	24.	108.	63.
46	25.	108.	67.
47	25.	108.	71.
48	26.	108.	74.
49	27.	138.	80.
50	32.	292.	99.
51	41.	583.	142.
52	56.	889.	245.
53	72.	1121.	376.
54	90.	1297.	553.
55	103.	1453.	1049.
56	111.	1580.	1341.
57	116.	1677.	1526.
58	120.	1786.	1669.
59	124.	1922.	1808.
60	127.	2052.	1942.
61	131.	2220.	2113.
62	138.	2709.	2646.
63	149.	3544.	3450.

65	167.	4950.	4883.
66	167.	4898.	4896.
67	160.	4306.	4368.
68	151.	3577.	3660.
69	144.	3014.	3082.
70	139.	2616.	2665.
71	134.	2293.	2333.
72	131.	2049.	2079.
73	128.	1854.	1955.
74	122.	1569.	1743.
75	113.	1157.	1420.
76	103.	751.	1052.
77	94.	455.	724.
78	87.	275.	492.
79	81.	166.	444.
80	74.	100.	392.
81	68.	59.	343.
82	62.	34.	297.
83	57.	20.	255.
84	52.	12.	219.
85	48.	5.	187.
86	45.	2.	160.
87	42.	2.	144.
88	39.	2.	131.
89	36.	2.	120.
90	34.	2.	109.
91	32.	2.	99.
92	30.	2.	91.
93	28.	2.	83.
94	27.	2.	76.
95	25.	2.	69.
96	24.	2.	63.
97	23.	2.	58.
98	21.	2.	53.
99	21.	2.	48.
100	20.	2.	44.
SUM			62768.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	4896.	2386.	654.	628.	62768.
INCHES		18.04	19.78	19.78	19.78
AC-FT		1184.	1298.	1298.	1298.

********** ********** ********** ********** **********

```
                                        PEAK    6-HOUR   24-HOUR   72-HOUR      AREA
HYDROGRAPH AT          1              5104.     2460.      663.      637.      1.23
ROUTED TO              1              4896.     2386.      654.      628.      1.23
```

MCDONNELL DOUGLAS AUTOMATION COMPANY -- ST. LOUIS MESSAGE OF THE DAY

```
*****************************************************************
*                                                               *
*                        LABOR HOLIDAY SCHEDULE                 *
*                                                               *
*      THE ST. LOUIS ASP/JES SYSTEMS WILL DISCONTINUE OPERATIONS AT *
*      0830, SUNDAY, 3 SEPTEMBER.  NORMAL OPERATIONS WILL RESUME AT *
*      0130, TUESDAY, 5 SEPTEMBER.                              *
*                                                               *
*      HAVE A HAPPY HOLIDAY.                                    *
*                                                               *
*****************************************************************
```

MCDONNELL DOUGLAS AUTOMATION COMPANY -- ST. LOUIS
OS/MVT RELEASE 21.7 COMPUTER SYSTEM SY0

ASP JOB NO. = 1839 JOBNAME = LANG0316 START TIME = 09.46.24 START DATE = 08/30/78

* * * * * * * * * * STEP RESOURCES * * * * * * * * * *

STEPNAME	COND CODE	COMP CODE	CORE USED	REGION REQUEST	DASD TRKS	DISK UNITS	TAPE UNITS	DASD I/O (MIN)	TAPE I/O (MIN)	CPU (MIN)	STEP TIME (MIN)	STEP MRU
GO	0000		194 K	194 K	100	1	0	.109	.000	.003	.058	.22

* TOTAL JOB USAGE * * * * * * MAIN RESOURCE UNIT SUMMARY * * * * * *

CPU (MIN)	I/O (MIN)	CPU USAGE (MRU)	RESOURCE OCCUPANCY (MRU) CORE	DASD TRKS	DISK UNITS	TAPE UNITS	INIT/TERM (MRU)	JOB TOTAL (MRU)
.003	.109	.03	.12	.00	.02	.00	.05	.22

********* ONE OR MORE STEPS IN THIS JOB UTILIZED A PROPRIETARY PACKAGE *********

CLIENT CHARGE NO. 1560972
CLIENT DEFINED SUB-ACC'TING
CLIENT DESCRIPTOR
PROGRAM NUMBER

*** RUN LIMITS ***
CPU (MIN) .50 DEFAULT PROGRAMMER NAME FIELD GED
I/O (MIN) 3.00 DEFAULT JOB ENTERED SYSTEM 09.45.39 08/30/78
LINES (1000) 12 DEFAULT
CARDS (100) 40 DEFAULT

APPENDIX 4

REFERENCES

APSHAWA DAMS

APPENDIX 4

REFERENCES

APSHAWA DAMS

Written Documents

1.	Specifications for 1912 works	Unknown
2.	Letter to Morris R. Sherrard from Mr. A.W. Cuddeback with attached documents	Dated July 5, 1912
3.	Letter of Morris R. Sherrard To State Water Supply Commission	Dated July 8, 1912
4.	Visit Report	Dated Oct. 19, 1912
5.	Visit Report	Dated Nov. 30, 1912
6.	Visit Report	
7.	Letter to the Apshawa Lake Realty Co., Inc.	Dated Aug. 26, 1913
8.	Descriptive Report - Unsigned	Unknown
9.	Letter from Browne-Pandullo & Assoc. to Dept of Conservation & Economic Development Attached Documents (9-1) Description (9-2) 10 Photos of Inlet Stream, Main Spillway, reservoir, etc.	Dated June 11, 1968
10.	Letter to Mr. Dirk C. Hoffman Bureau of Water Control By Kenneth R. Kawkswell, Health Officer and Attached Hand Written Reports	Dated July 25, 1974

Drawings

1.	Plan showing reinforcement of the concrete dam of the Apshawa Dam	Dated May 10, 1912

Others

1. Eby, C.F. 1976, Soil Survey of Morris County, New Jersey, U.S. Department of Argriculture, Soil Conservation Service, 111 pp.

2. Lewis,J.V. and H.B. Kummel, 1924, The Geology of New Jersey, Bulletin 14, Geological Survey of New Jersey, Trenton, New Jersey, 146 pp.

3. Lucey, C.S., 1972, Geology of Morris County in Brief, State of New Jersey, Bureau of Geology and Topography, Trenton, New Jersey, 13 pp.

4. Minard, J.P. W.W. Holman, A.R. Jumikis, 1953, Engineering Soil Survey of New Jersey, Report No. 9, Morris County, Rutgers University, New Brunswick, New Jersey, 86 pp.

5. Rogers, F.C., D.R. Lueder, and G.H. Obear, 1951, Engineering Soil Survey of New Jersey, Report No. 3, Passaic County, Rutgers University, New Brunswick, New Jersey, 45 pp.

6. Widmer, K., 1964, The Geology and Geography of New Jersey, Volume 19, The New Jersey Historical Series, D. Van Nostrand Co., Inc., Princeton, New Jersey 193 pp.

7. Wolfe, P.E., 1977, The Geology and Landscapes of New Jersey, Crane, Russak & Company, Inc., New York, New York, 351 pp.